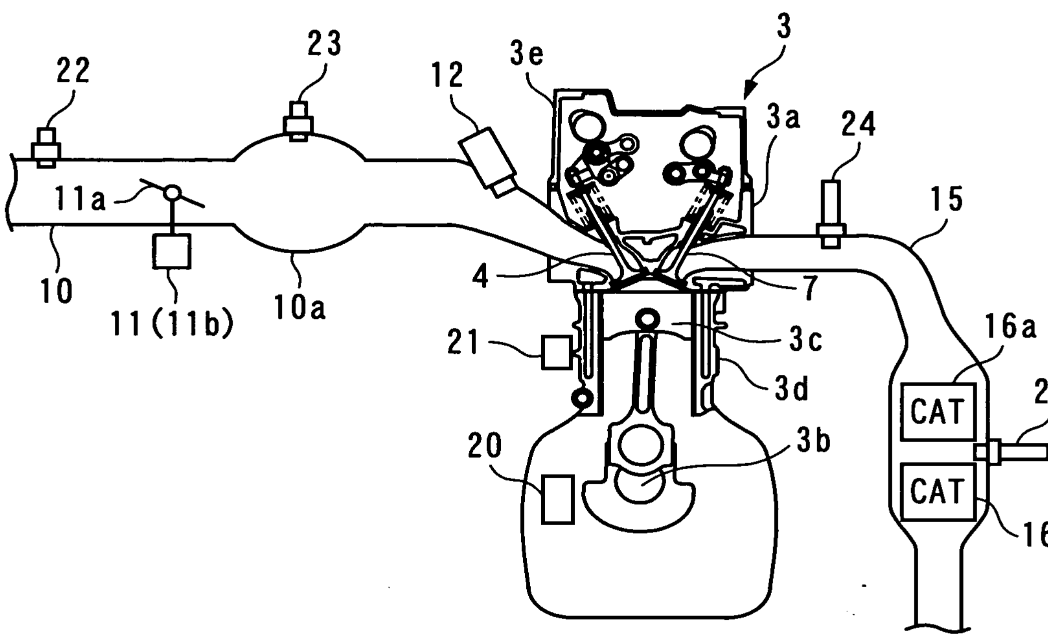
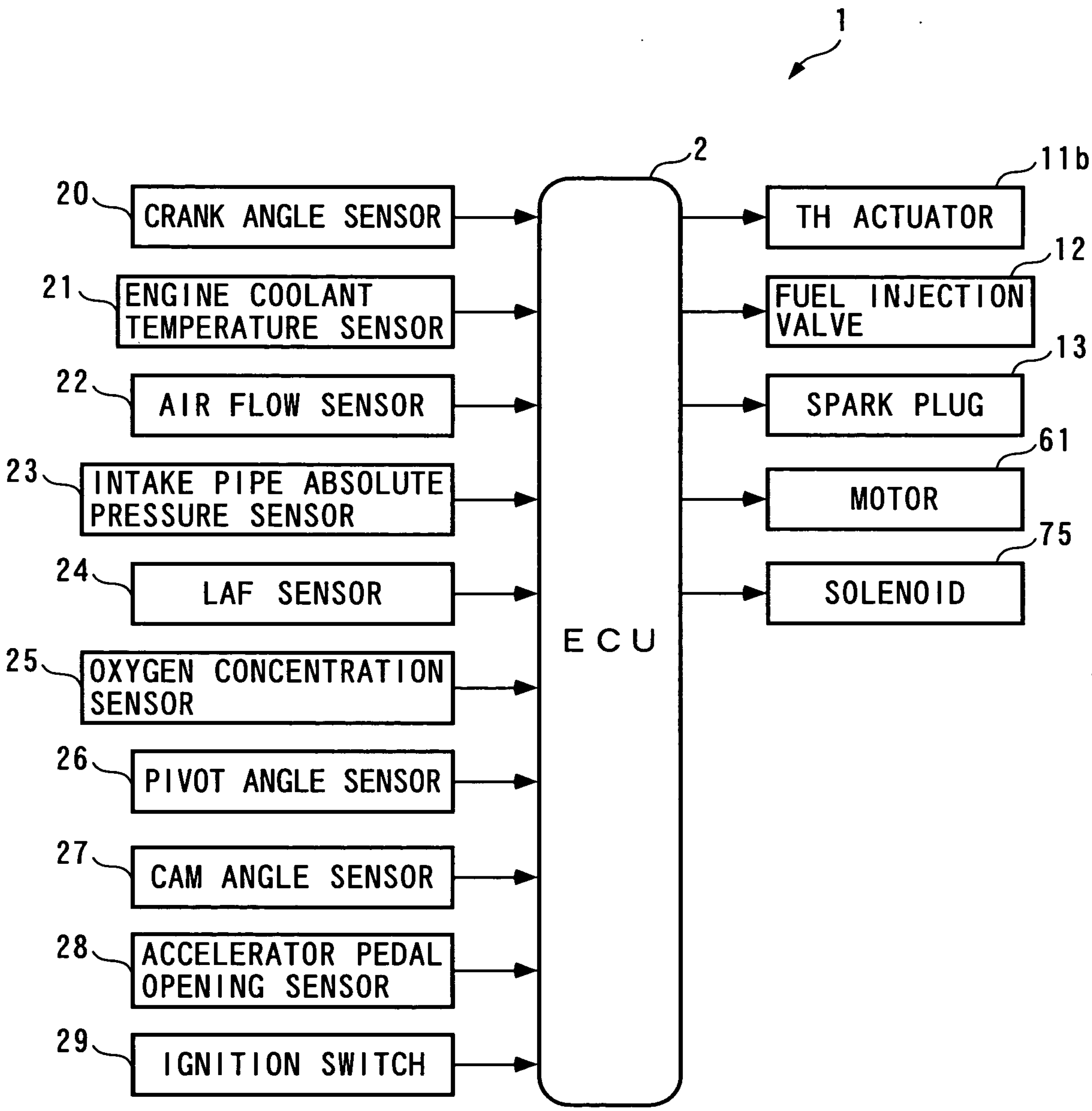
Title: Intake Air Amount Control System for Internal Combustion Engine
Inventor: YASUI, et al.
Appln. No.: New Application
Docket No.: 108419-00082

FIG. 1



F I G. 2


1
2
20
CRANK ANGLE SENSOR
21
ENGINE COOLANT TEMPERATURE SENSOR
22
AIR FLOW SENSOR
23
INTAKE PIPE ABSOLUTE PRESSURE SENSOR
24
LAF SENSOR
25
OXYGEN CONCENTRATION SENSOR
26
PIVOT ANGLE SENSOR
27
CAM ANGLE SENSOR
28
ACCELERATOR PEDAL OPENING SENSOR
29
IGNITION SWITCH
ECU
11b
TH ACTUATOR
12
FUEL INJECTION VALVE
13
SPARK PLUG
61
MOTOR
75
SOLENOID

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Inventor: YASUI, et al.
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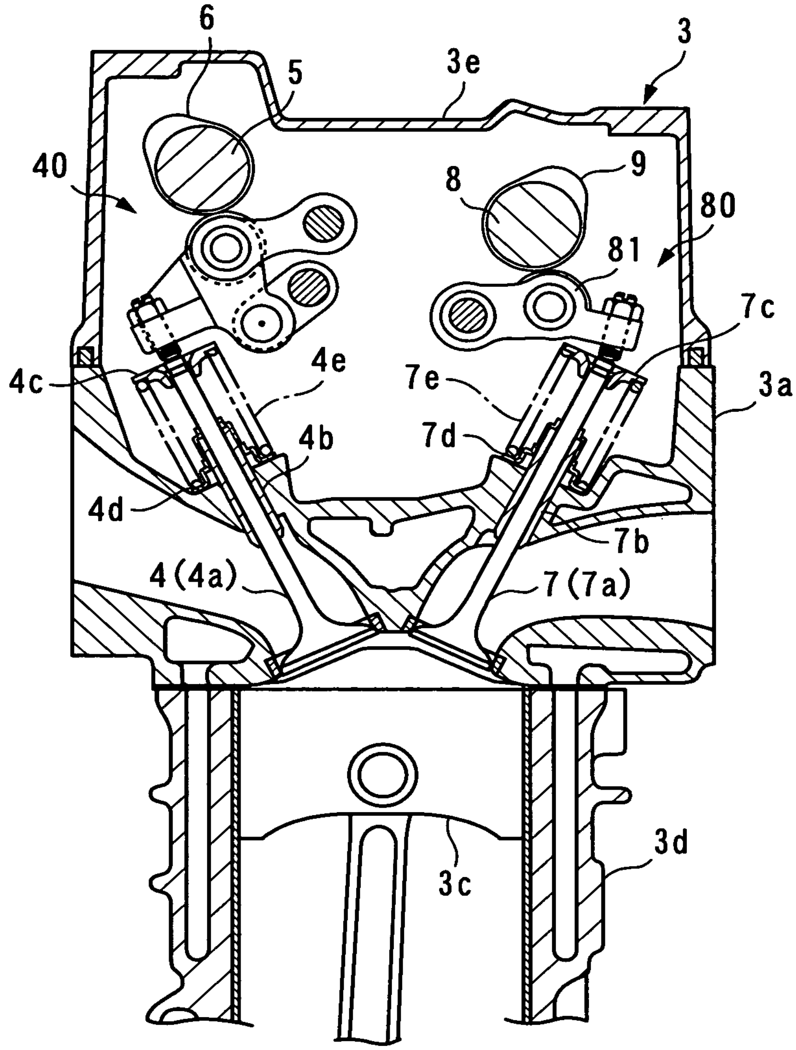
FIG. 3



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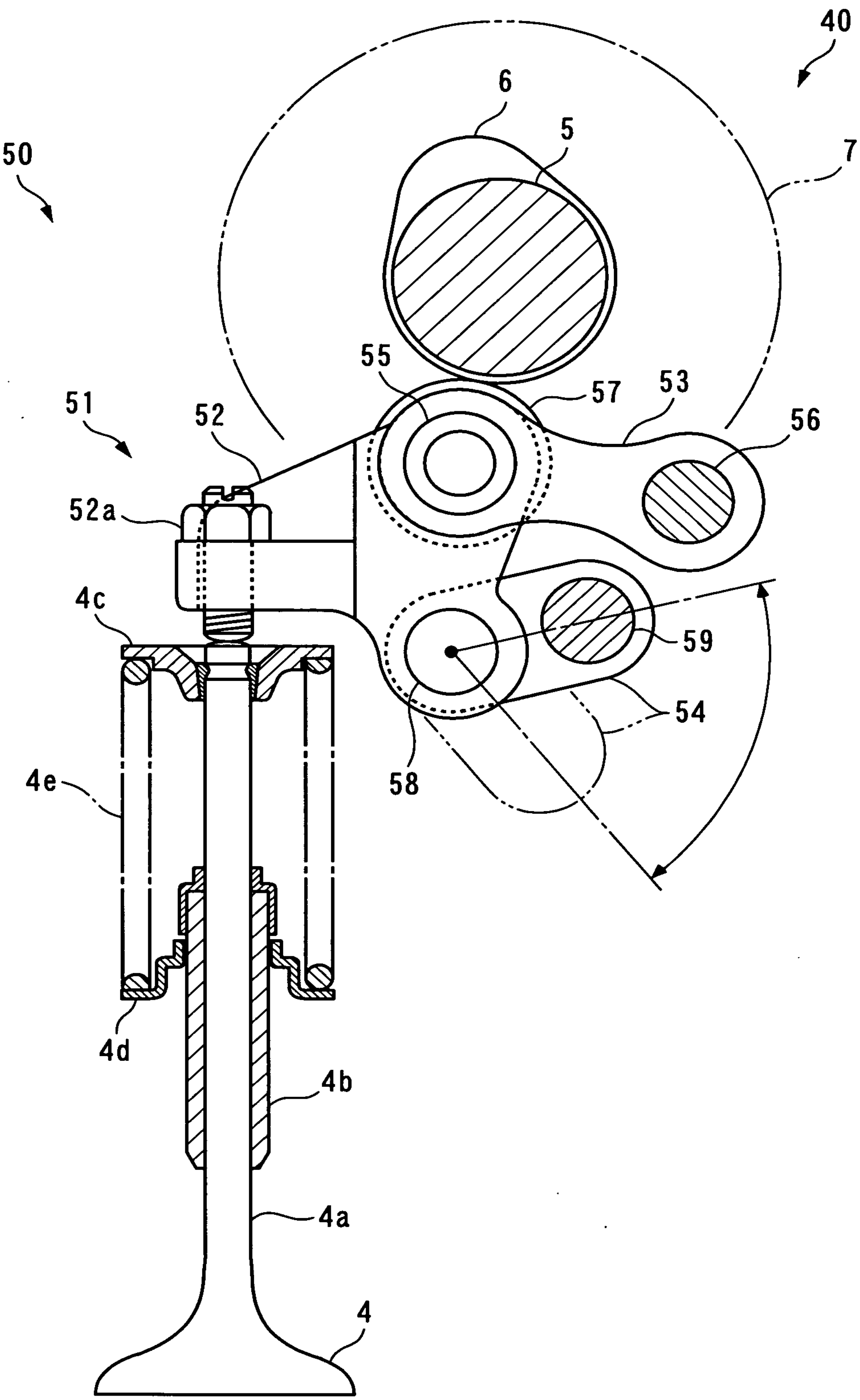
F I G. 4



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Inventor: YASUI, et al.
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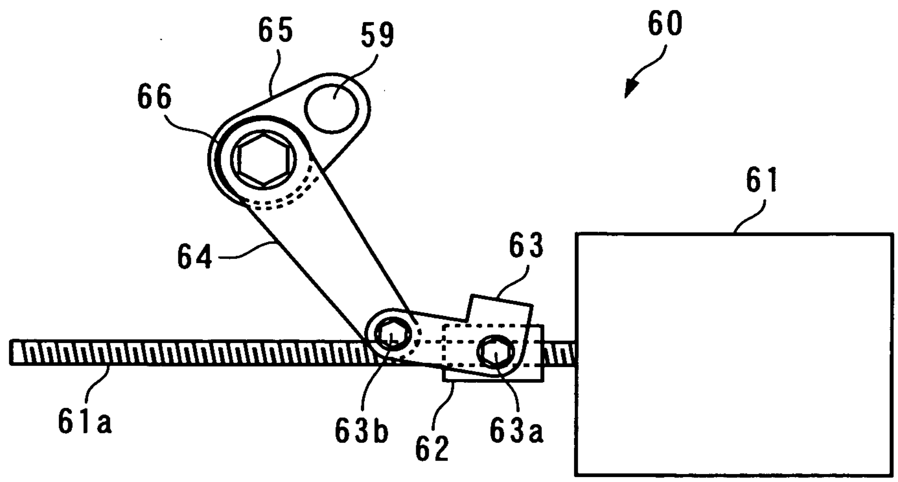
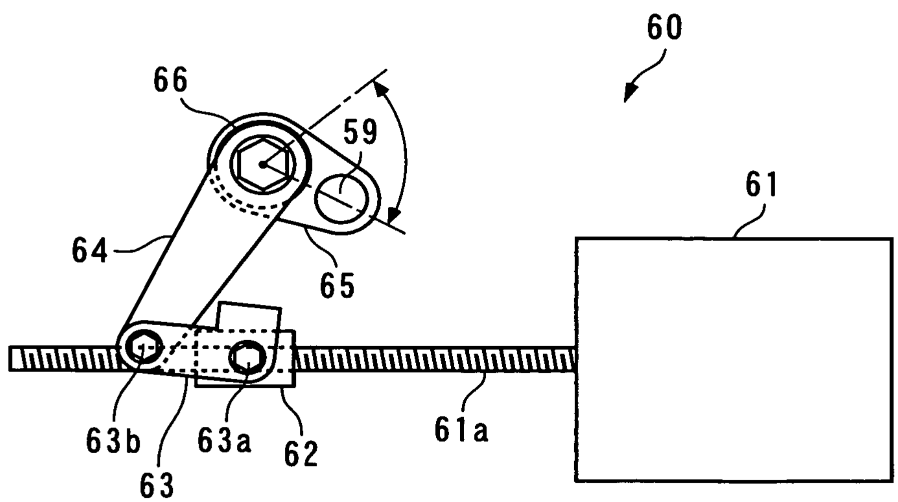
F I G. 5

(a)



(b)



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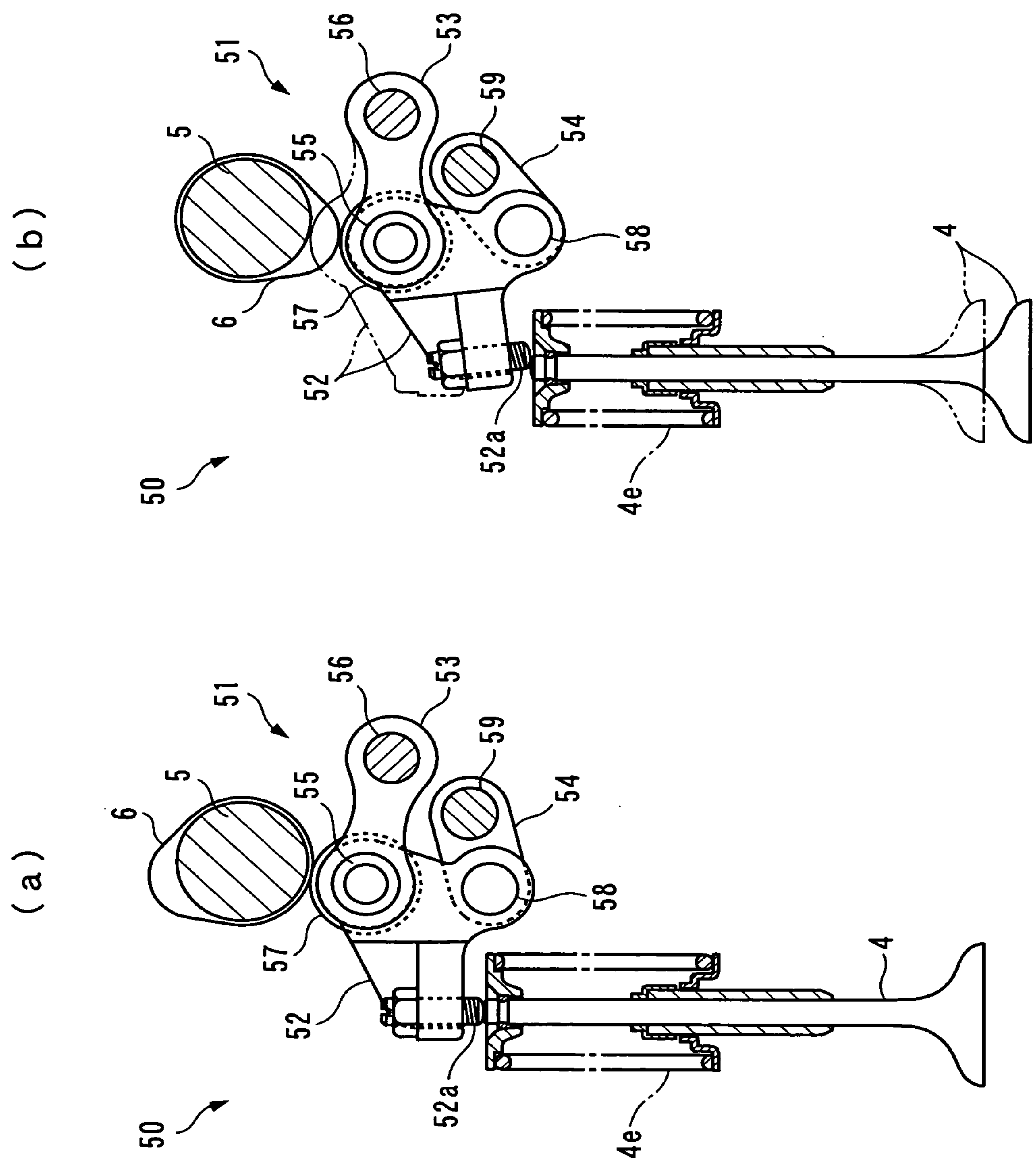
F I G. 6



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Inventor: YASUI, et al.
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FIG. 7

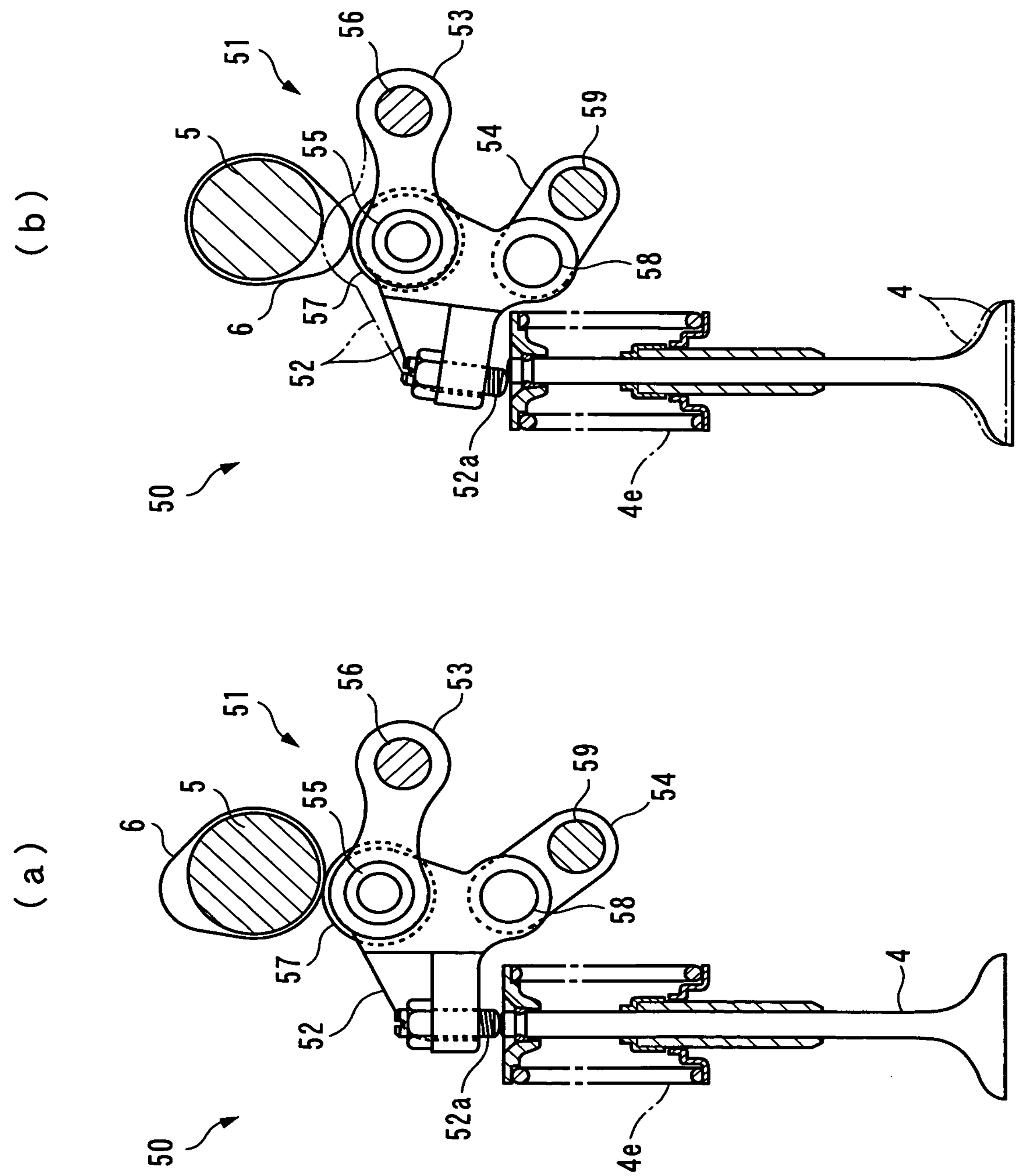

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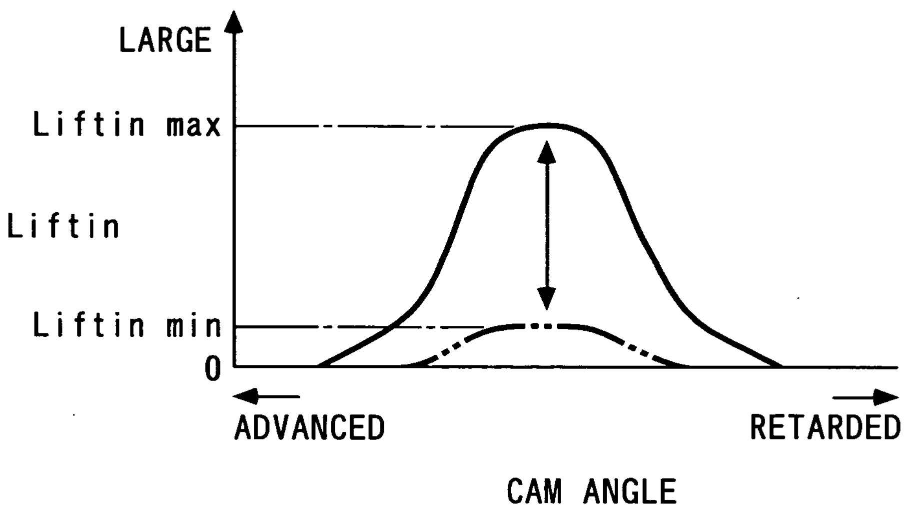
FIG. 8



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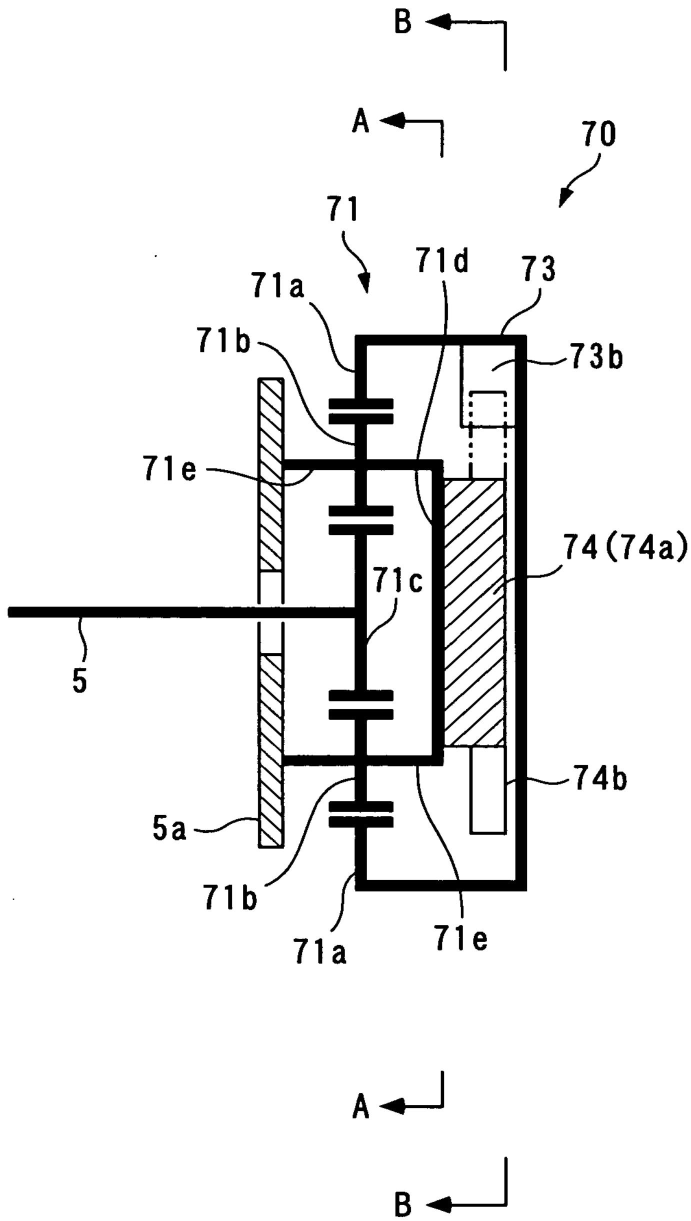
F I G. 9



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Inventor: YASUI, et al.
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FIG. 10

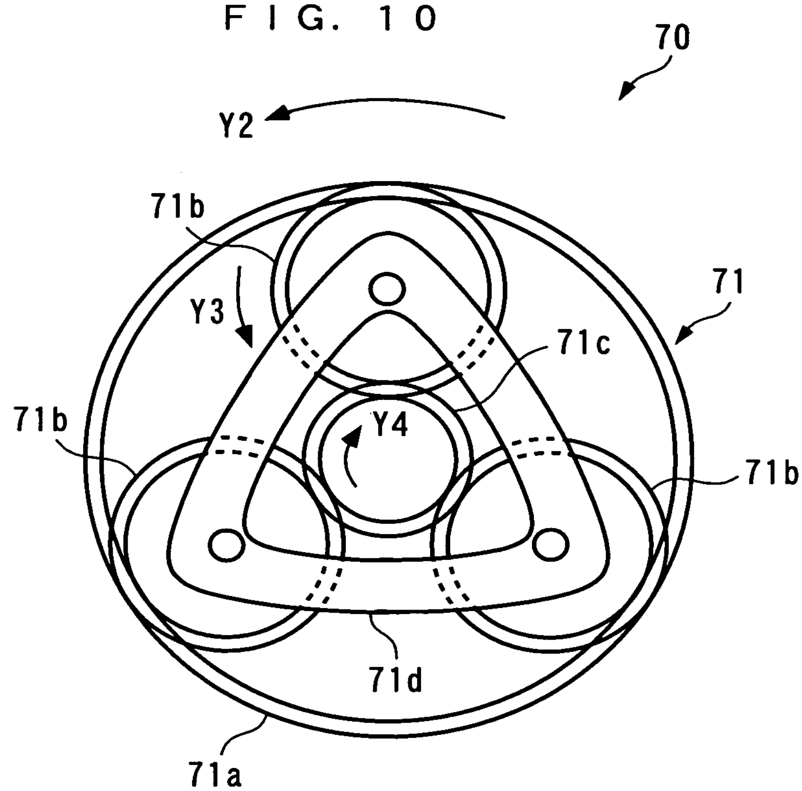

FIG. 11

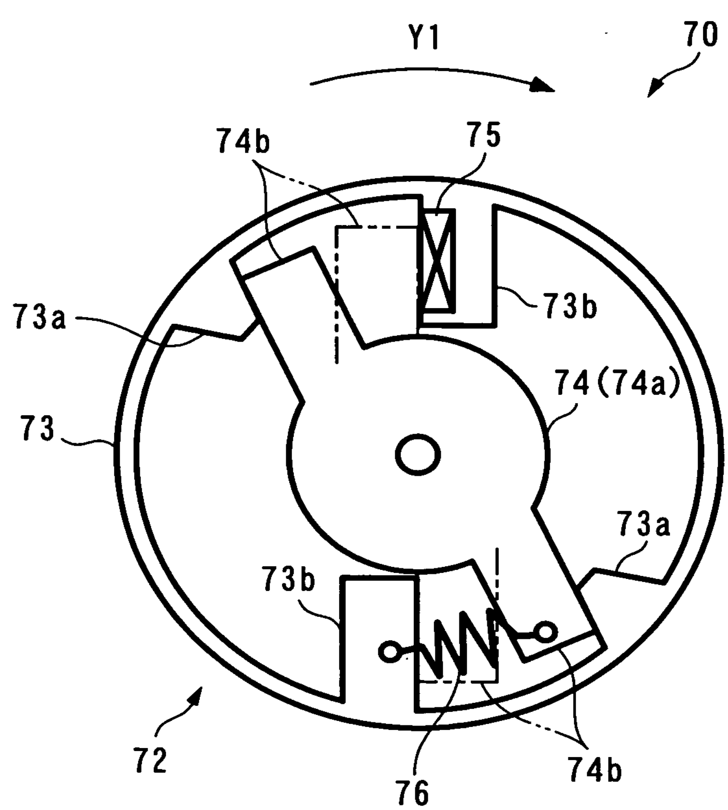

FIG. 12

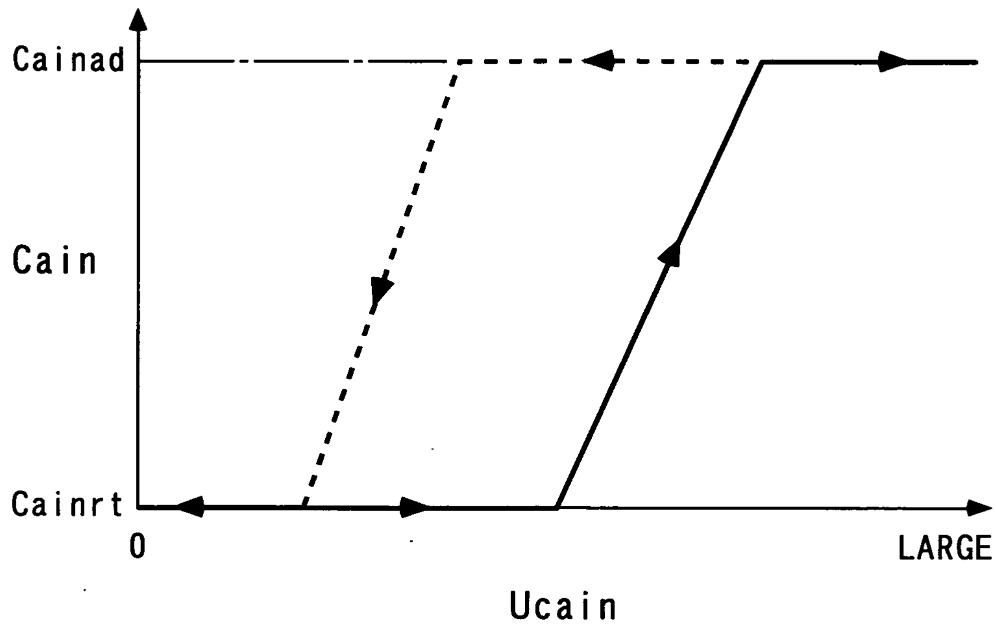

FIG. 13

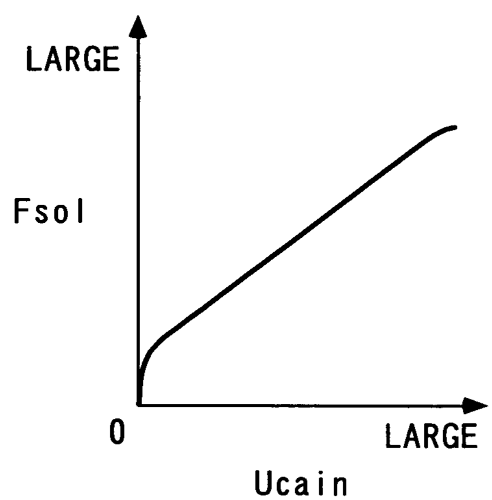

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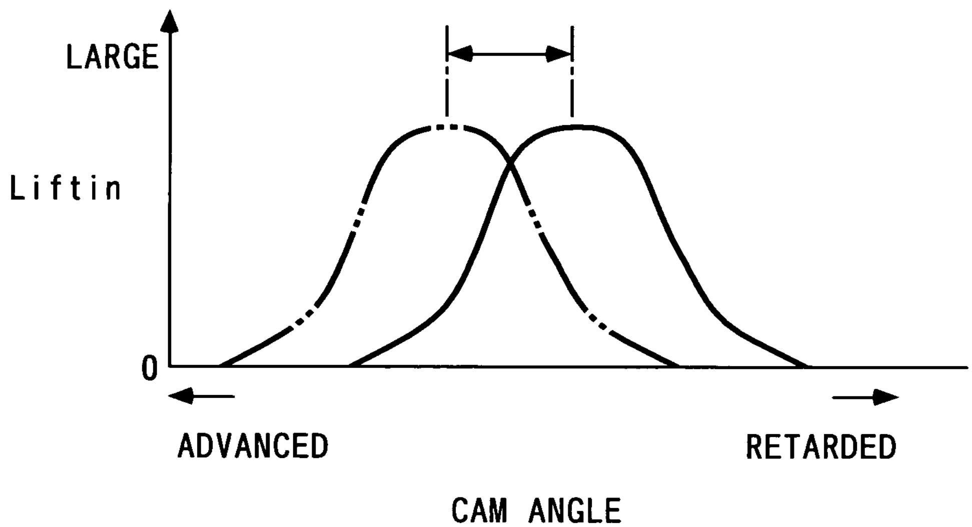
FIG. 14



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Inventor: YASUI, et al.
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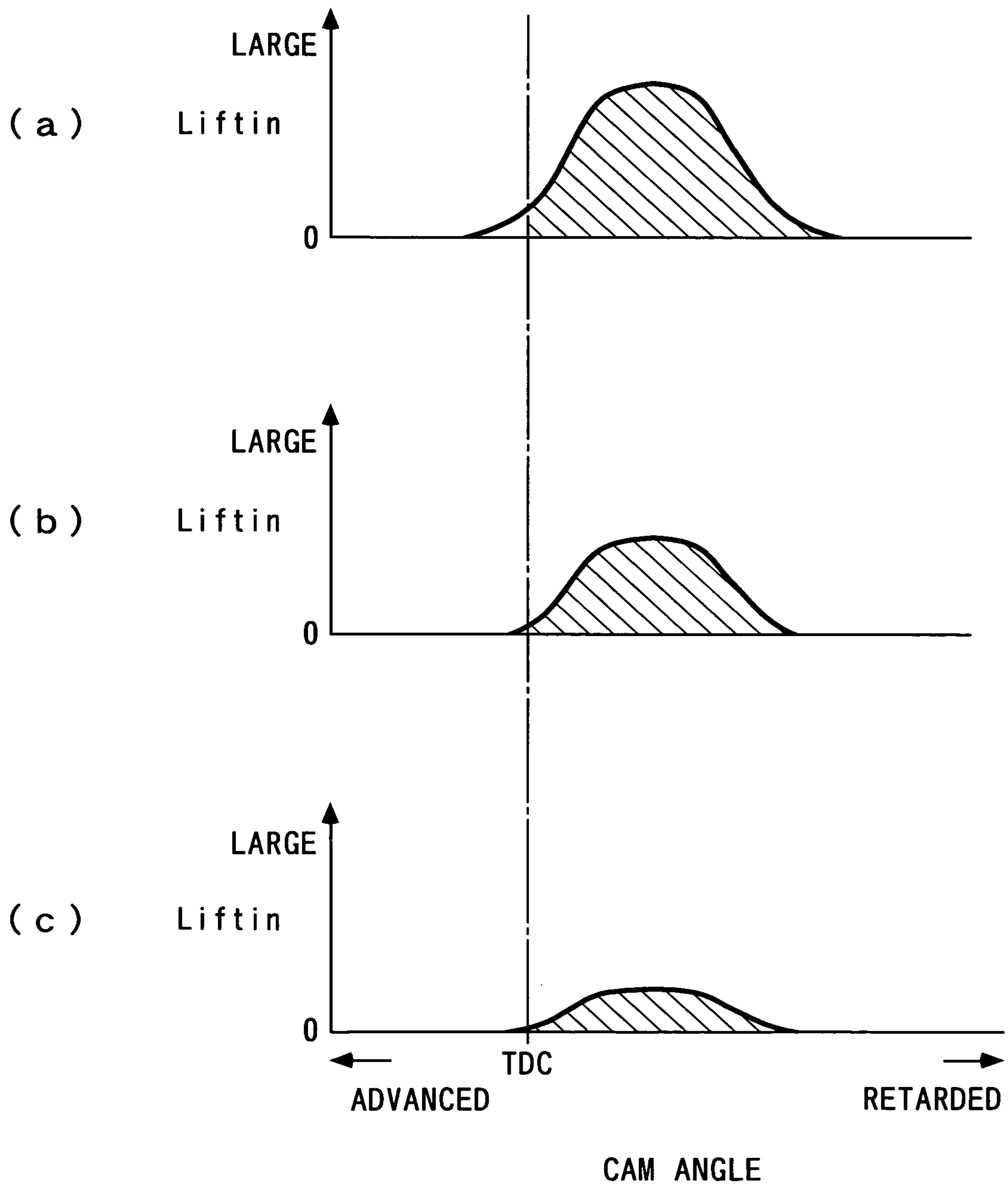
FIG. 15



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Inventor: YASUI, et al.
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FIG. 16

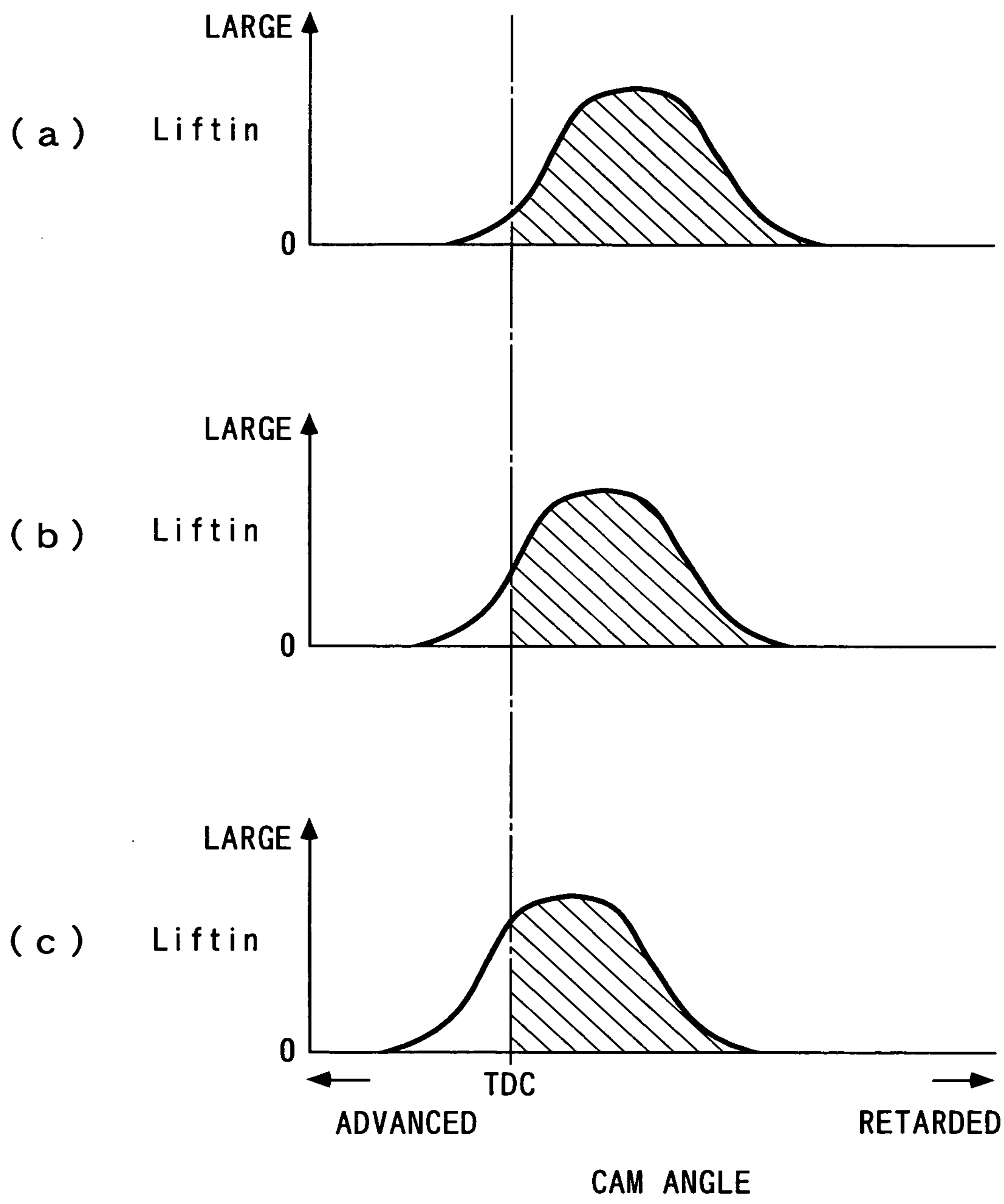

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FIG. 17

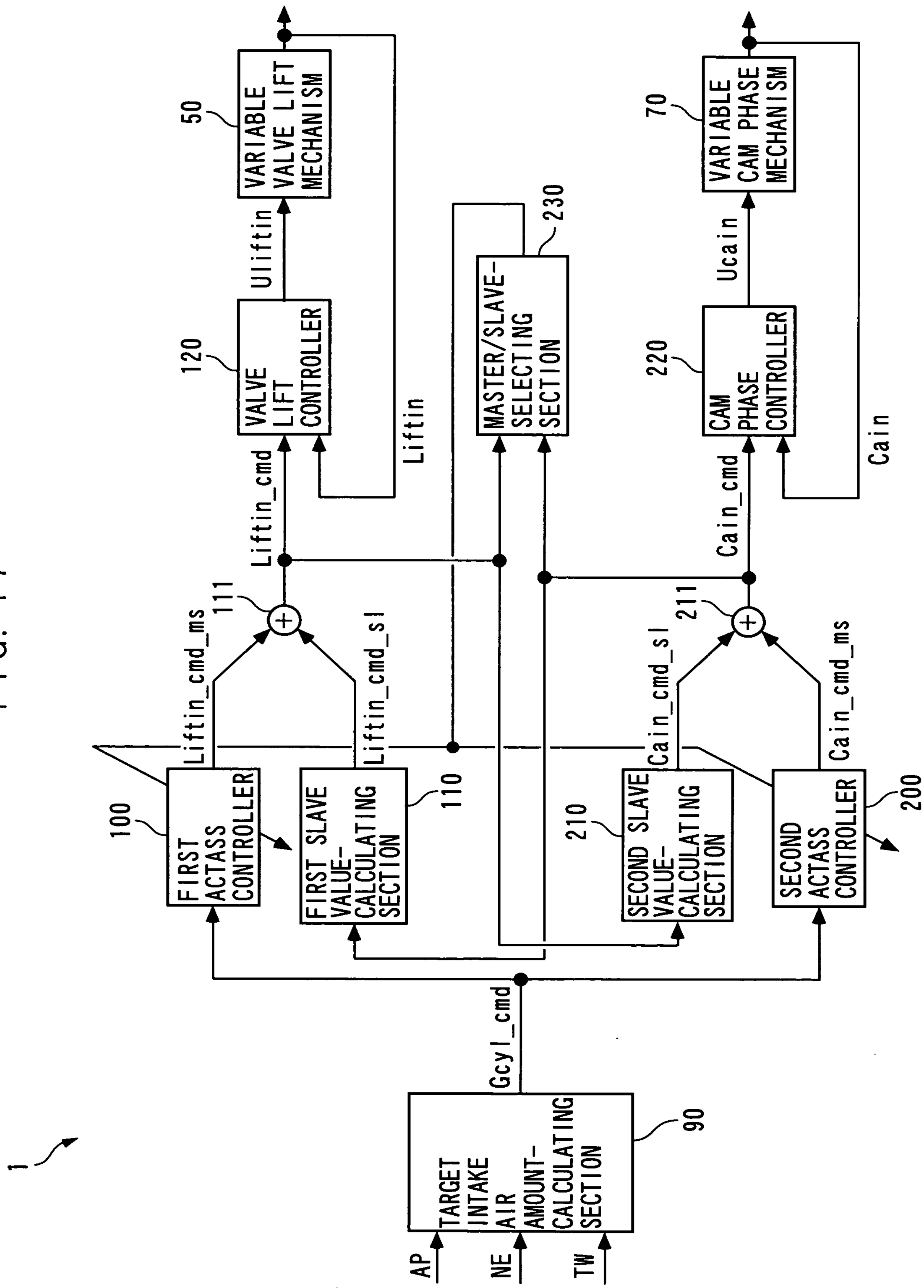

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FIG. 18

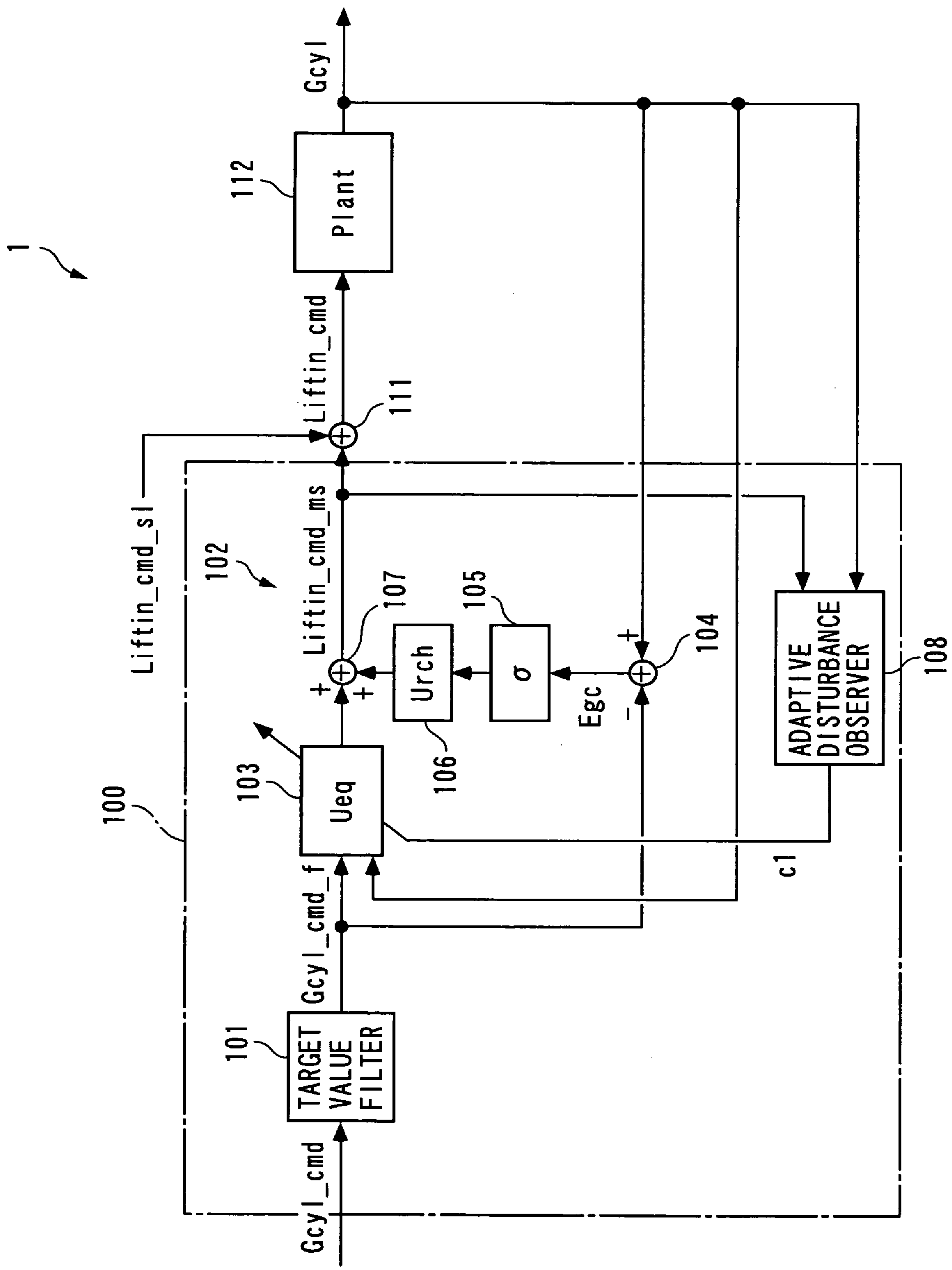

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FIG. 19

$$Gcyl(k)=Gth(k)-\frac{VB\cdot[PBA(k)-PBA(k-1)]}{R\cdot TB} \quad \cdots\cdots (1)$$

$$Gcyl\_cmd\_f(k)=-POLE\_f\cdot Gcyl\_cmd\_f(k-1)+(1+POLE\_f)\cdot Gcyl\_cmd(k) \quad \cdots\cdots (2)$$

$$Liftin\_cmd\_ms(k)=Ueq(k)+Urch(k) \quad \cdots\cdots (3)$$

$$\begin{aligned} Ueq(k)=\frac{1}{b1}\{&(1-a1-POLE)\cdot Gcyl(k)+(POLE-a2)\cdot Gcyl(k-1)\\ &-b2\cdot Liftin\_cmd\_ms(k-1)-c1(k)+Gcyl\_cmd\_f(k+1)\\ &+(POLE-1)\cdot Gcyl\_cmd\_f(k)-POLE\cdot Gcyl\_cmd\_f(k-1)\} \end{aligned} \quad \cdots\cdots (4)$$

$$Urch(k)=-\frac{Krch}{b1}\cdot\sigma(k) \quad \cdots\cdots (5)$$

$$\sigma(k)=Egc(k)+POLE\cdot Egc(k-1) \quad \cdots\cdots (6)$$

$$Egc(k)=Gcyl(k)-Gcyl\_cmd\_f(k) \quad \cdots\cdots (7)$$

$$\begin{aligned} Gcyl(k+1)=&a1\cdot Gcyl(k)+a2\cdot Gcyl(k-1)\\ &+b1\cdot Liftin\_cmd(k)+b2\cdot Liftin\_cmd(k-1) \end{aligned} \quad \cdots\cdots (8)$$

$$\begin{aligned} Gcyl(k+1)=&a1\cdot Gcyl(k)+a2\cdot Gcyl(k-1)\\ &+b1\cdot Liftin\_cmd\_ms(k)+b2\cdot Liftin\_cmd\_ms(k-1) \end{aligned} \quad \cdots\cdots (9)$$

FIG. 20

$$c1(k)=c1(k-1)+\frac{Pdov}{1+Pdov}\cdot e\_dov(k) \quad \cdots\cdots (10)$$

$$e\_dov(k)=Gcyl(k)-Gcyl\_hat(k) \quad \cdots\cdots (11)$$

$$Gcyl\_hat(k)=\theta(k-1)^{T}\cdot\zeta(k) \quad \cdots\cdots (12)$$

$$\theta(k)^{T}=[a1,a2,b1,b2,c1(k)] \quad \cdots\cdots (13)$$

$$\zeta(k)^{T}=[Gcyl(k-1),Gcyl(k-2),Liftin\_cmd\_ms(k-1),Liftin\_cmd\_ms(k-2),1] \quad \cdots\cdots (14)$$

$$\begin{aligned}c1(k)=&-Krch\cdot\sigma(k)+(1-a1-POLE)\cdot Gcyl(k)+(POLE-a2)\cdot Gcyl(k-1)\\&-b2\cdot Liftin\_cmd\_ms(k-1)+Gcyl\_cmd\_f(k+1)\\&+(POLE-1)\cdot Gcyl\_cmd\_f(k)-POLE\cdot Gcyl\_cmd\_f(k-1)\end{aligned} \quad \cdots\cdots (15)$$

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FIG. 21

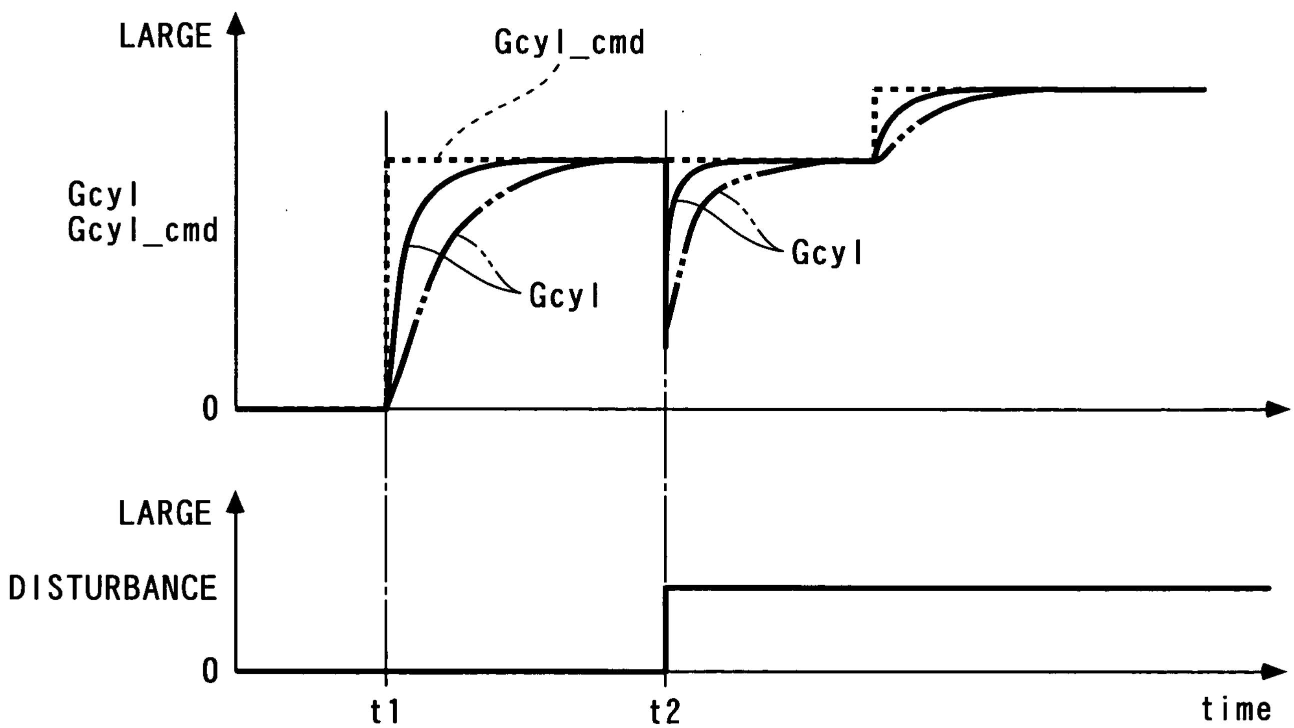

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FIG. 22

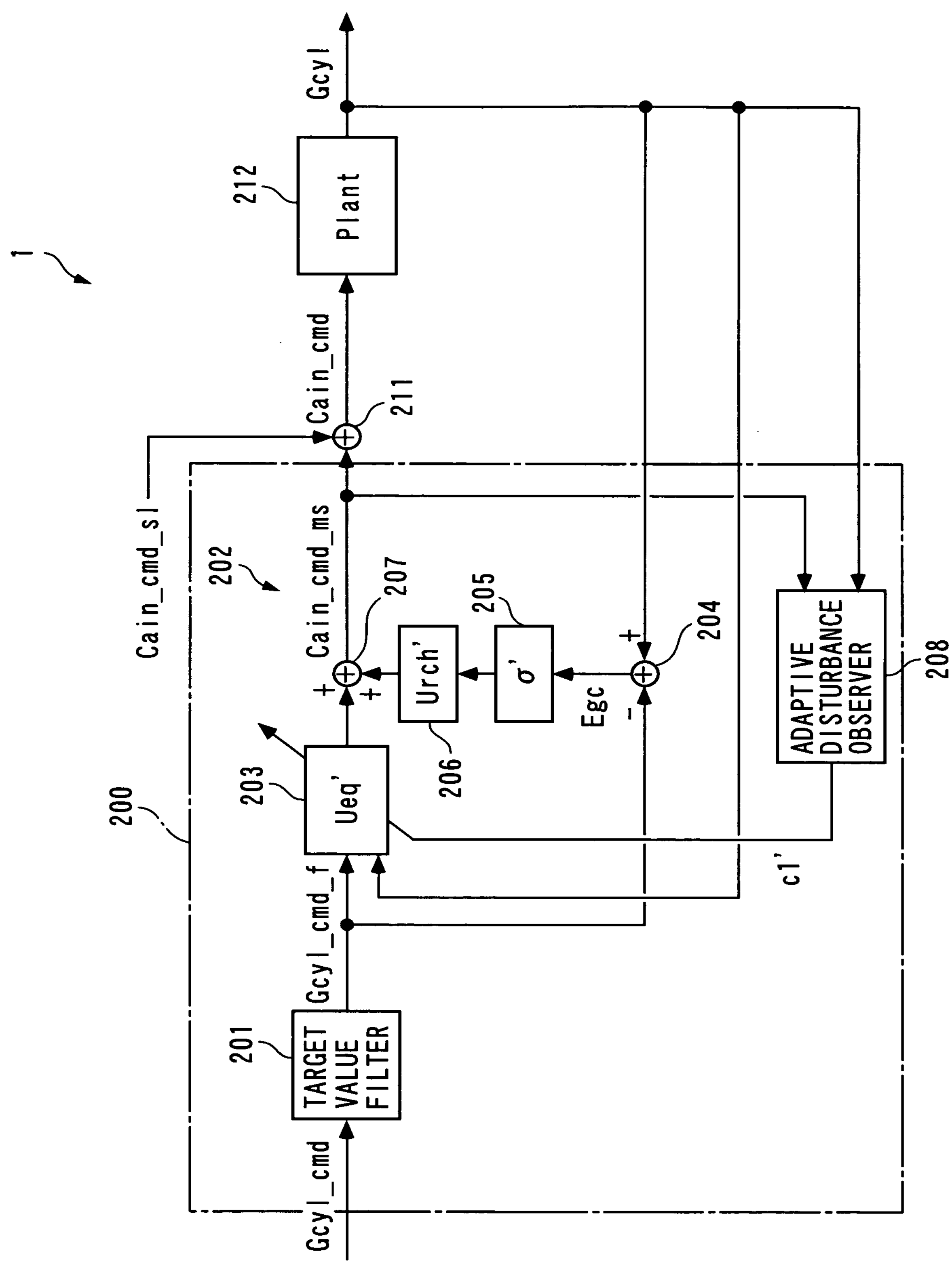

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FIG. 23

$$Gcyl\_cmd\_f(k) = -POLE\_f \cdot Gcyl\_cmd\_f(k-1) + (1+POLE\_f) \cdot Gcyl\_cmd(k) \quad \cdots\cdots (16)$$

$$Cain\_cmd\_ms(k) = Ueq'(k) + Urch'(k) \quad \cdots\cdots (17)$$

$$\begin{aligned} Ueq'(k) = \frac{1}{b1'} \{ & (1-a1'-POLE') \cdot Gcyl(k) + (POLE'-a2') \cdot Gcyl(k-1) \\ & - b2' \cdot Cain\_cmd\_ms(k-1) - c1'(k) + Gcyl\_cmd\_f(k+1) \\ & + (POLE'-1) \cdot Gcyl\_cmd\_f(k) - POLE' \cdot Gcyl\_cmd\_f(k-1) \} \end{aligned} \quad \cdots\cdots (18)$$

$$Urch'(k) = -\frac{Krch'}{b1'} \cdot \sigma'(k) \quad \cdots\cdots (19)$$

$$\sigma'(k) = Egc(k) + POLE' \cdot Egc(k-1) \quad \cdots\cdots (20)$$

$$Egc(k) = Gcyl(k) - Gcyl\_cmd\_f(k) \quad \cdots\cdots (21)$$

$$\begin{aligned} Gcyl(k+1) = & a1' \cdot Gcyl(k) + a2' \cdot Gcyl(k-1) \\ & + b1' \cdot Cain\_cmd(k) + b2' \cdot Cain\_cmd(k-1) \end{aligned} \quad \cdots\cdots (22)$$

$$\begin{aligned} Gcyl(k+1) = & a1' \cdot Gcyl(k) + a2' \cdot Gcyl(k-1) \\ & + b1' \cdot Cain\_cmd\_ms(k) + b2' \cdot Cain\_cmd\_ms(k-1) \end{aligned} \quad \cdots\cdots (23)$$

F I G. 24

$$c1'(k)=c1'(k-1)+\frac{Pdov'}{1+Pdov'}\cdot e\_dov'(k) \qquad \cdots\cdots (24)$$

$$e\_dov'(k)=Gcyl(k)-Gcyl\_hat'(k) \qquad \cdots\cdots (25)$$

$$Gcyl\_hat'(k)=\theta'(k-1)^{T}\cdot\zeta'(k) \qquad \cdots\cdots (26)$$

$$\theta'(k)^{T}=[a1',a2',b1',b2',c1'(k)] \qquad \cdots\cdots (27)$$

$$\zeta'(k)^{T}=[Gcyl(k-1),Gcyl(k-2),Cain\_cmd\_ms(k-1),Cain\_cmd\_ms(k-2),1] \qquad \cdots\cdots (28)$$

$$\begin{aligned}c1'(k)=&-Krch'\cdot\sigma'(k)+(1-a1'-POLE')\cdot Gcyl(k)+(POLE'-a2')\cdot Gcyl(k-1)\\&-b2'\cdot Cain\_cmd\_ms(k-1)+Gcyl\_cmd\_f(k+1)\\&+(POLE'-1)\cdot Gcyl\_cmd\_f(k)-POLE'\cdot Gcyl\_cmd\_f(k-1)\end{aligned} \qquad \cdots\cdots (29)$$

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F I G. 25

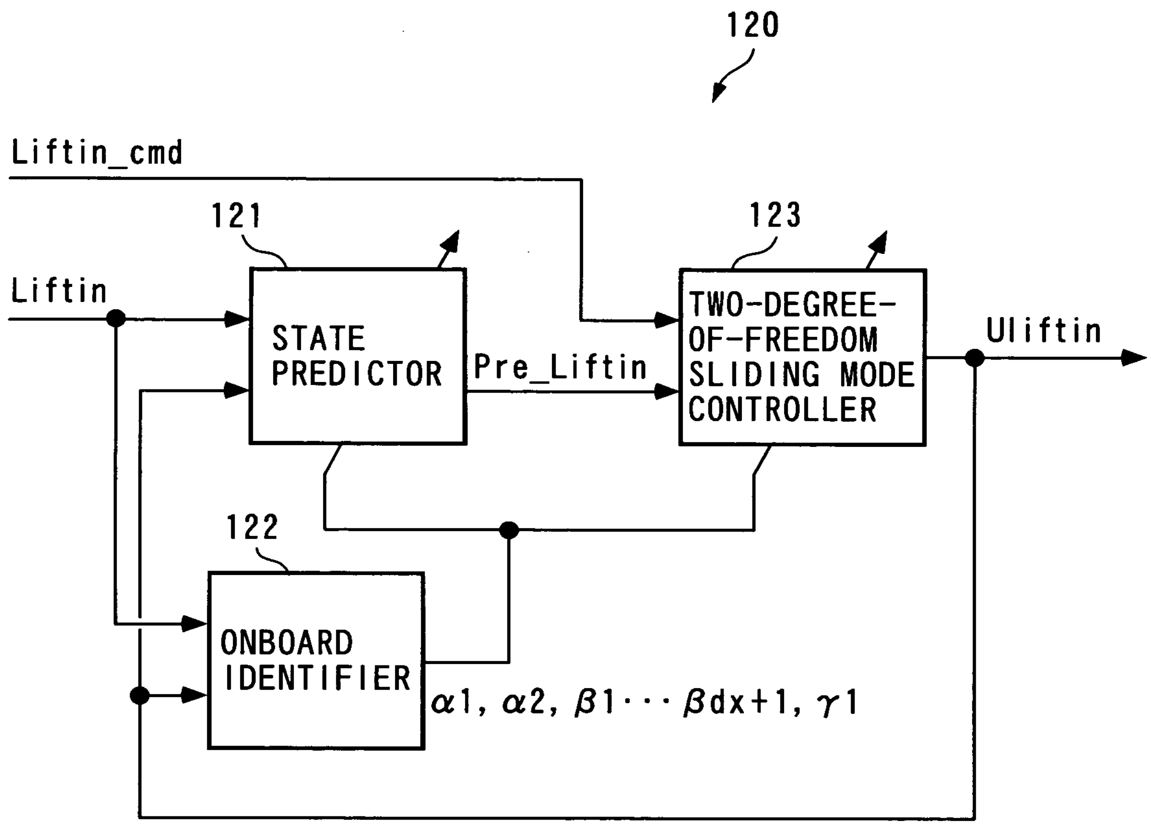

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FIG. 26

$$\mathrm{Liftin}(n+1) = a1'' \cdot \mathrm{Liftin}(n) + a2'' \cdot \mathrm{Liftin}(n-1) + b1'' \cdot \mathrm{Uliftin}(n-dx) + b2'' \cdot \mathrm{Uliftin}(n-dx-1) \quad \cdots\cdots (30)$$

$$\boldsymbol{A} = \begin{bmatrix} a1'' & a2'' \\ 1 & 0 \end{bmatrix} \quad \cdots\cdots (31)$$

$$\boldsymbol{B} = \begin{bmatrix} b1'' & b2'' \\ 0 & 0 \end{bmatrix} \quad \cdots\cdots (32)$$

$$\begin{aligned} \mathrm{Liftin}(n+dx) = {} & \alpha 1(n) \cdot \mathrm{Liftin}(n) + \alpha 2(n) \cdot \mathrm{Liftin}(n-1) \\ & + \beta 1(n) \cdot \mathrm{Uliftin}(n-1) + \beta 2(n) \cdot \mathrm{Uliftin}(n-2) \\ & + \cdots\cdots + \beta dx(n) \cdot \mathrm{Uliftin}(n-dx) \\ & + \beta dx+1(n) \cdot \mathrm{Uliftin}(n-dx-1) \quad \cdots\cdots (33) \end{aligned}$$

$\alpha 1$: 1ST ROW-1ST COLUMN COMPONENT OF $\boldsymbol{A}^{dx}$
$\alpha 2$: 1ST ROW-2ND COLUMN COMPONENT OF $\boldsymbol{A}^{dx}$

$$\beta j \ (j=1 \sim dx+1) : \begin{cases} \text{1ST ROW-1ST COLUMN COMPONENT } (j=1) \text{ OF } \boldsymbol{A}^{j-1}\boldsymbol{B} \\ \text{1ST ROW-1ST COLUMN COMPONENT OF } \boldsymbol{A}^{j-1}\boldsymbol{B} \\ \text{+1ST ROW-2ND COLUMN COMPONENT } (j=2 \sim dx) \text{ OF } \boldsymbol{A}^{j-2}\boldsymbol{B} \\ \text{1ST ROW-2ND COLUMN COMPONENT } (j=dx+1) \text{ OF } \boldsymbol{A}^{j-2}\boldsymbol{B} \end{cases}$$

$$\begin{aligned} \mathrm{Pre\_Liftin}(n) = {} & \alpha 1(n) \cdot \mathrm{Liftin}(n) + \alpha 2(n) \cdot \mathrm{Liftin}(n-1) \\ & + \beta 1(n) \cdot \mathrm{Uliftin}(n-1) + \beta 2(n) \cdot \mathrm{Uliftin}(n-2) \\ & + \cdots\cdots + \beta dx(n) \cdot \mathrm{Uliftin}(n-dx) \\ & + \beta dx+1(n) \cdot \mathrm{Uliftin}(n-dx-1) \\ & + \gamma 1(n) \quad \cdots\cdots (34) \end{aligned}$$

FIG. 27

$$\theta x(n)=\theta x(n-1)+KP(n)\cdot ide(n) \quad \cdots\cdots (35)$$

$$KP(n)=\frac{P(n)\cdot \zeta x(n)}{1+\zeta x(n)^{T}\cdot P(n)\cdot \zeta x(n)} \quad \cdots\cdots (36)$$

$$P(n+1)=\frac{1}{\lambda 1}\left[I-\frac{\lambda 2\cdot P(n)\cdot \zeta x(n)\cdot \zeta x(n)^{T}}{\lambda 1+\lambda 2\cdot \zeta x(n)^{T}\cdot P(n)\cdot \zeta x(n)}\right]\cdot P(n) \quad \cdots\cdots (37)$$

I : UNIT MATRIX OF ORDER dx+2
λ1, λ2 : WEIGHTING PARAMETER

$$\begin{aligned} ide(n) &= Liftin\_hat(n)-Liftin(n) \\ &= \theta x(n-1)^{T}\cdot \zeta x(n)-Liftin(n) \end{aligned} \quad \cdots\cdots (38)$$

$$\theta x(n)^{T}=[\alpha 1(n), \alpha 2(n), \beta 1(n), \beta 2(n), \cdots, \beta dx+1(n), \gamma 1(n)] \quad \cdots\cdots (39)$$

$$\begin{aligned} \zeta x(n)^{T}=[&Liftin(n-dx), Liftin(n-dx-1), Uliftin(n-dx-1), \\ &Uliftin(n-dx-2), \cdots\cdots, Uliftin(n-2dx-1), 1] \end{aligned} \quad \cdots\cdots (40)$$

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FIG. 28

$$Liftin\_cmd\_f(n) = -POLE\_f'' \cdot Liftin\_cmd\_f(n-1) + (1+POLE\_f'') \cdot Liftin\_cmd(n) \quad \cdots\cdots (41)$$

$$Uliftin(n) = Ueq''(n) + Urch''(n) \quad \cdots\cdots (42)$$

$$\begin{aligned} Ueq''(n) = \frac{1}{\beta 1(n)} \{ & -POLE'' \cdot Pre\_Liftin(n) + Pre\_Liftin(n-1) \\ & + POLE'' \cdot Pre\_Liftin(n-2) - \alpha 1(n) \cdot Pre\_Liftin(n-dx+1) \\ & - \alpha 2(n) \cdot Pre\_Liftin(n-dx) - \beta 2(n) \cdot Uliftin(n-1) \\ & - \cdots - \beta dx(n) \cdot Uliftin(n-dx+1) \\ & - \beta dx+1(n) \cdot Uliftin(n-dx) - \gamma 1(n) \\ & + Liftin\_cmd\_f(n) + POLE'' \cdot Liftin\_cmd\_f(n-1) \\ & - Liftin\_cmd\_f(n-1) - POLE'' \cdot Liftin\_cmd\_f(n-2) \} \end{aligned} \quad \cdots\cdots (43)$$

$$Urch''(n) = -\frac{Krch''}{\beta 1(n)} \cdot Pre\_\sigma''(n) \quad \cdots\cdots (44)$$

$$Pre\_\sigma''(n) = Pre\_E\_lf(n) + POLE'' \cdot Pre\_E\_lf(n-1) \quad \cdots\cdots (45)$$

$$Pre\_E\_lf(n) = Pre\_Liftin(n) - Liftin\_cmd\_f(n) \quad \cdots\cdots (46)$$

FIG. 29

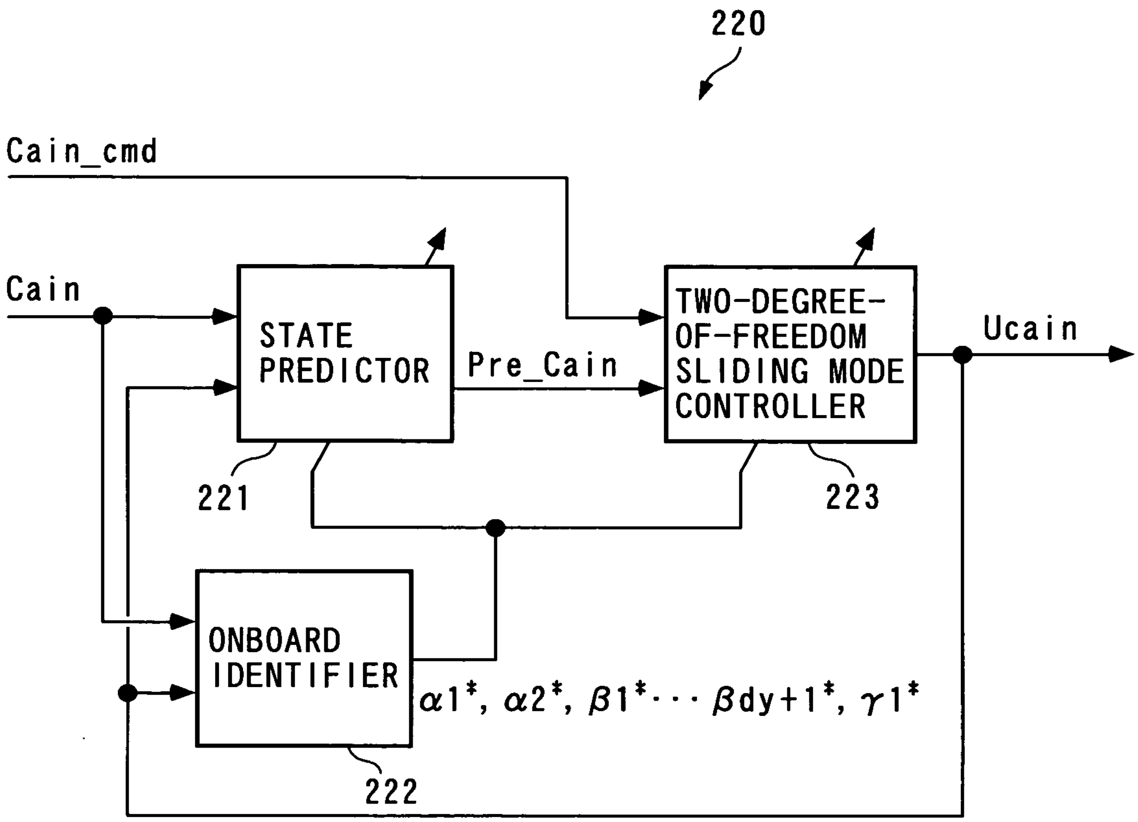
220
Cain_cmd
Cain
STATE PREDICTOR
Pre_Cain
TWO-DEGREE-OF-FREEDOM SLIDING MODE CONTROLLER
Ucain
221
223
ONBOARD IDENTIFIER
α1*, α2*, β1*··· βdy+1*, γ1*
222

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FIG. 30

$$Cain(n+1)=a1^{*}\cdot Cain(n)+a2^{*}\cdot Cain(n-1) +b1^{*}\cdot Ucain(n-dy)+b2^{*}\cdot Ucain(n-dy-1) \quad \cdots\cdots (47)$$

$$\boldsymbol{A}y=\begin{bmatrix} a1^{*} & a2^{*} \\ 1 & 0 \end{bmatrix} \quad \cdots\cdots (48)$$

$$\boldsymbol{B}y=\begin{bmatrix} b1^{*} & b2^{*} \\ 0 & 0 \end{bmatrix} \quad \cdots\cdots (49)$$

$$\begin{aligned} Cain(n+dy)=&\alpha1^{*}(n)\cdot Cain(n)+\alpha2^{*}(n)\cdot Cain(n-1) \\ &+\beta1^{*}(n)\cdot Ucain(n-1)+\beta2^{*}(n)\cdot Ucain(n-2) \\ &+\cdots\cdots+\beta dy^{*}(n)\cdot Ucain(n-dy) \\ &+\beta dy+1^{*}(n)\cdot Ucain(n-dy-1) \end{aligned} \quad \cdots\cdots (50)$$

$\alpha1^{*}$: 1ST ROW-1ST COLUMN COMPONENT OF $\boldsymbol{A}y^{dy}$
$\alpha2^{*}$: 1ST ROW-2ND COLUMN COMPONENT OF $\boldsymbol{A}y^{dy}$

$$\underset{(j=1\sim dy+1)}{\beta j^{*}}:\begin{cases} \text{1ST ROW-1ST COLUMN COMPONENT } (j=1) \text{ OF } \boldsymbol{A}y^{j-1}\boldsymbol{B}y \\ \text{1ST ROW-1ST COLUMN COMPONENT OF } \boldsymbol{A}y^{j-1}\boldsymbol{B}y \\ \quad +\text{1ST ROW-2ND COLUMN COMPONENT } (j=2\sim dy) \text{ OF } \boldsymbol{A}y^{j-2}\boldsymbol{B}y \\ \text{1ST ROW-2ND COLUMN COMPONENT } (j=dy+1) \text{ OF } \boldsymbol{A}y^{j-2}\boldsymbol{B}y \end{cases}$$

$$\begin{aligned} Pre\_Cain(n)=&\alpha1^{*}(n)\cdot Cain(n)+\alpha2^{*}(n)\cdot Cain(n-1) \\ &+\beta1^{*}(n)\cdot Ucain(n-1)+\beta2^{*}(n)\cdot Ucain(n-2) \\ &+\cdots\cdots+\beta dy^{*}(n)\cdot Ucain(n-dy) \\ &+\beta dy+1^{*}(n)\cdot Ucain(n-dy-1) \\ &+\gamma1^{*}(n) \end{aligned} \quad \cdots\cdots (51)$$

FIG. 31

$$\theta^*(n)=\theta^*(n-1)+KP^*(n)\cdot ide^*(n) \quad \cdots\cdots (52)$$

$$KP^*(n)=\frac{P^*(n)\cdot\zeta^*(n)}{1+\zeta^*(n)^T\cdot P^*(n)\cdot\zeta^*(n)} \quad \cdots\cdots (53)$$

$$P^*(n+1)=\frac{1}{\lambda 1^*}\left[I-\frac{\lambda 2^*\cdot P^*(n)\cdot\zeta^*(n)\cdot\zeta^*(n)^T}{\lambda 1^*+\lambda 2^*\cdot\zeta^*(n)^T\cdot P^*(n)\cdot\zeta^*(n)}\right]\cdot P^*(n) \quad \cdots\cdots (54)$$

I : UNIT MATRIX OF ORDER dy+2
$\lambda 1^*$, $\lambda 2^*$: WEIGHTING PARAMETER

$$\begin{aligned} ide^*(n)&=Cain\_hat(n)-Cain(n) \\ &=\theta^*(n-1)^T\cdot\zeta^*(n)-Cain(n) \end{aligned} \quad \cdots\cdots (55)$$

$$\theta^*(n)^T=[\alpha 1^*(n),\ \alpha 2^*(n),\ \beta 1^*(n),\ \beta 2^*(n),\ \cdots,\ \beta dy+1^*(n),\ \gamma 1^*(n)] \quad \cdots\cdots (56)$$

$$\zeta^*(n)^T=[Cain(n-dy), Cain(n-dy-1), Cain(n-dy-2), \cdots, Cain(n-2dy-1), 1] \quad \cdots\cdots (57)$$

FIG. 32

$$Cain\_cmd\_f(n)=-POLE\_f^{*}\cdot Cain\_cmd\_f(n-1)+(1+POLE\_f^{*})\cdot Cain\_cmd(n) \quad \cdots\cdots (58)$$

$$Ucain(n)=Ueq^{*}(n)+Urch^{*}(n) \quad \cdots\cdots (59)$$

$$\begin{aligned} Ueq^{*}(n)=\frac{1}{\beta 1^{*}(n)}\{&-POLE^{*}\cdot Pre\_Cain(n)+Pre\_Cain(n-1)\\ &+POLE^{*}\cdot Pre\_Cain(n-2)-\alpha 1^{*}(n)\cdot Pre\_Cain(n-dy+1)\\ &-\alpha 2^{*}(n)\cdot Pre\_Cain(n-dy)-\beta 2^{*}(n)\cdot Ucain(n-1)\\ &-\cdots-\beta dy^{*}(n)\cdot Ucain(n-dy+1)\\ &-\beta dy+1^{*}(n)\cdot Ucain(n-dy)-\gamma 1^{*}(n)\\ &+Cain\_cmd\_f(n)+POLE^{*}\cdot Cain\_cmd\_f(n-1)\\ &-Cain\_cmd\_f(n-1)-POLE^{*}\cdot Cain\_cmd\_f(n-2)\} \end{aligned} \quad \cdots\cdots (60)$$

$$Urch^{*}(n)=-\frac{Krch^{*}}{\beta 1^{*}(n)}\cdot Pre\_\sigma^{*}(n) \quad \cdots\cdots (61)$$

$$Pre\_\sigma^{*}(n)=Pre\_E\_ca^{*}(n)+POLE^{*}\cdot Pre\_E\_ca^{*}(n-1) \quad \cdots\cdots (62)$$

$$Pre\_E\_ca^{*}(n)=Pre\_Cain(n)-Cain\_cmd\_f(n) \quad \cdots\cdots (63)$$

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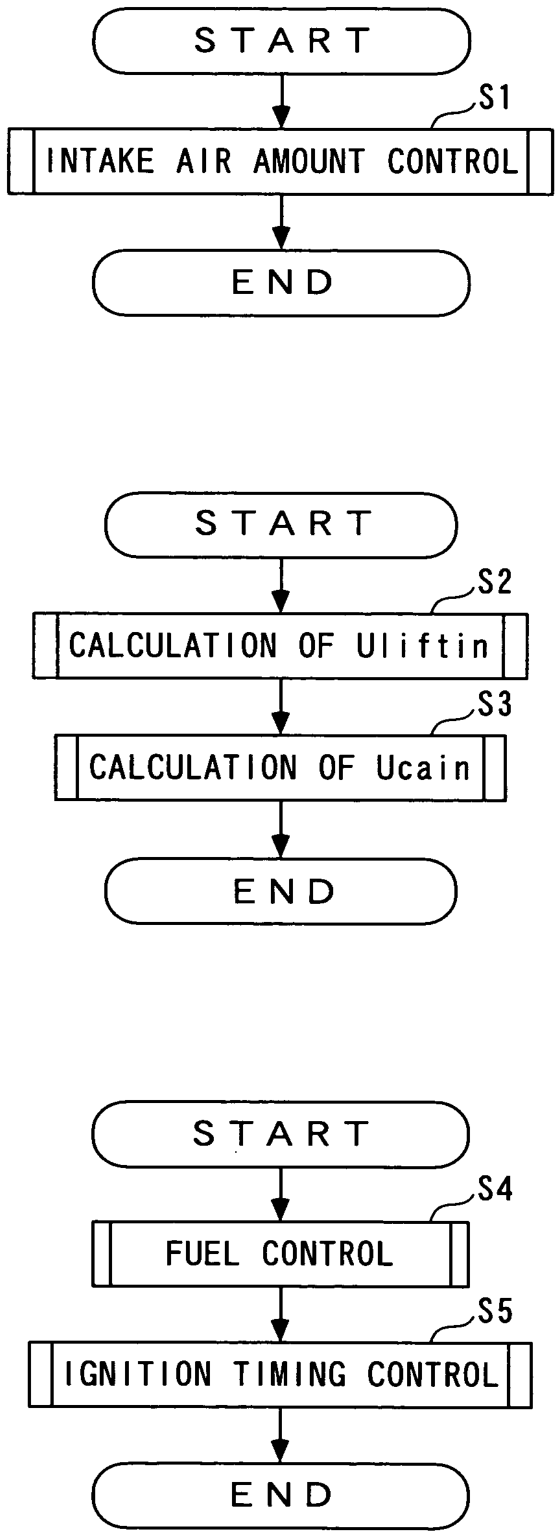
FIG. 33

(a)

(b)

(c)



F I G. 34

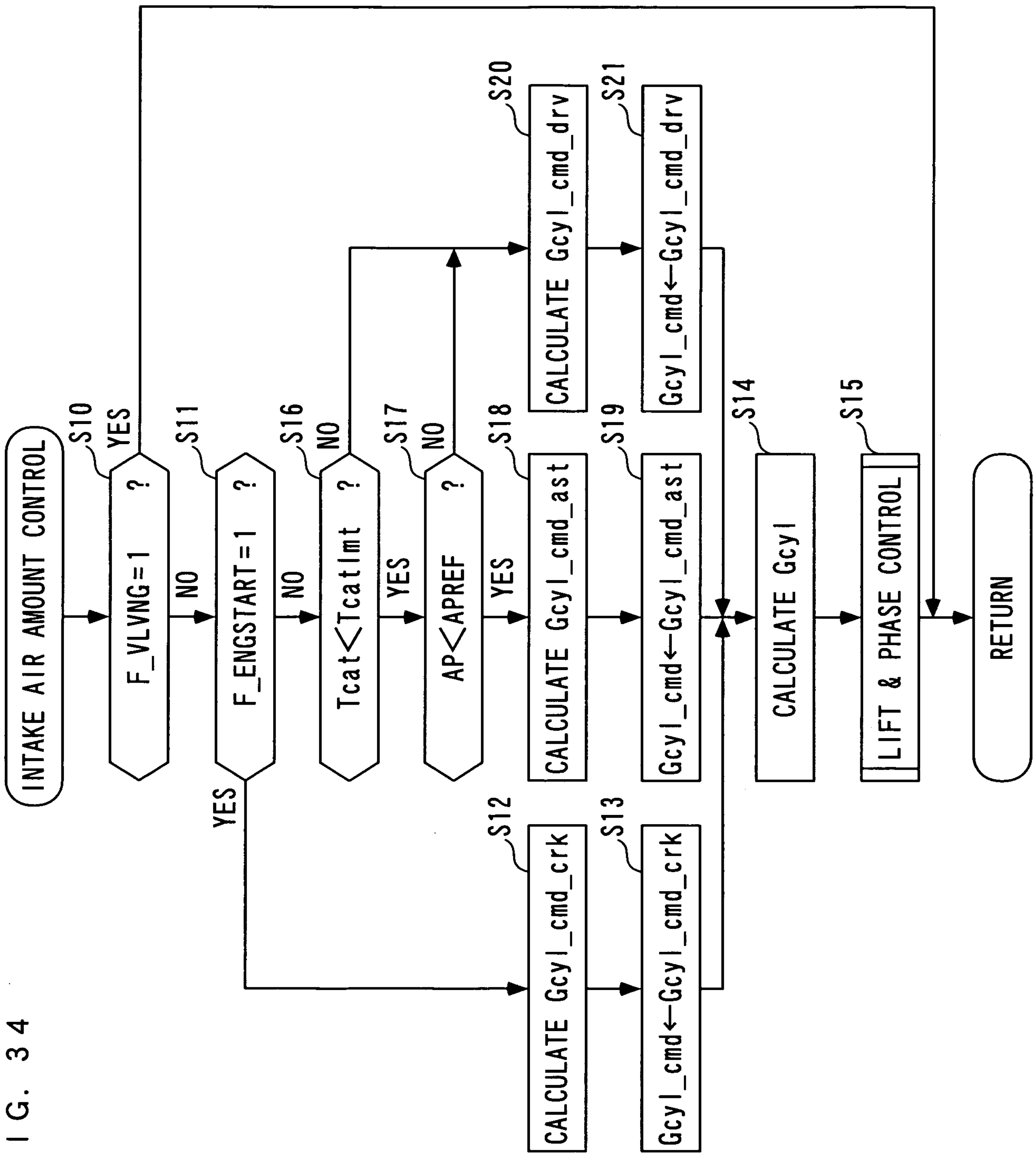

INTAKE AIR AMOUNT CONTROL
S10
F_VLVNG=1 ?
YES
NO
S11
F_ENGSTART=1 ?
YES
NO
S16
Tcat<Tcatlmt ?
NO
YES
S17
AP<APREF ?
NO
YES
S12
CALCULATE Gcyl_cmd_crk
S13
Gcyl_cmd←Gcyl_cmd_crk
S18
CALCULATE Gcyl_cmd_ast
S19
Gcyl_cmd←Gcyl_cmd_ast
S20
CALCULATE Gcyl_cmd_drv
S21
Gcyl_cmd←Gcyl_cmd_drv
S14
CALCULATE Gcyl
S15
LIFT & PHASE CONTROL
RETURN

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FIG. 35

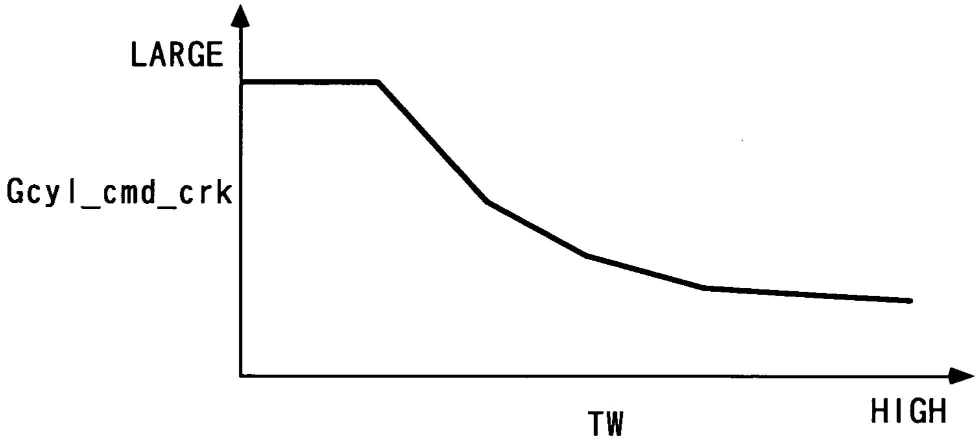

FIG. 36

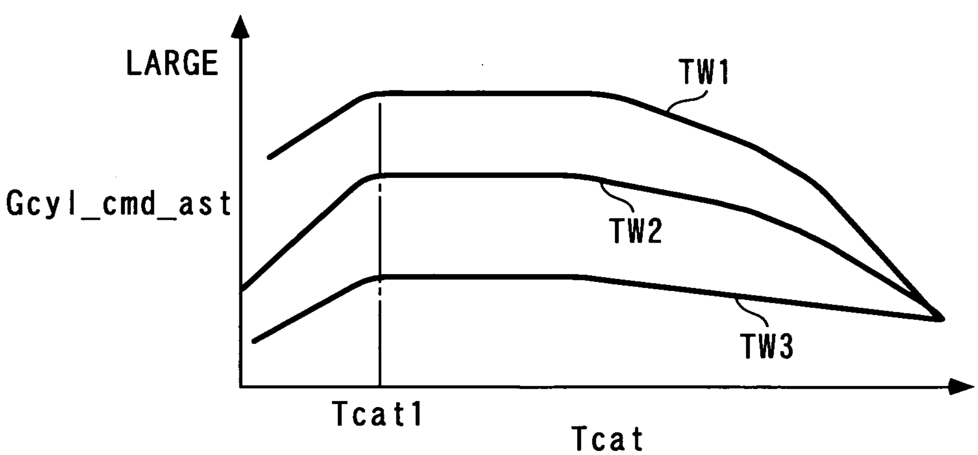

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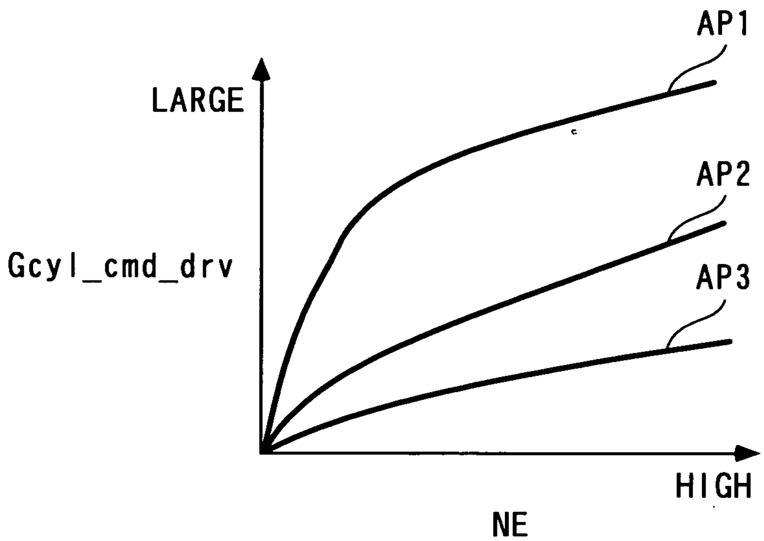
FIG. 37



F I G. 38

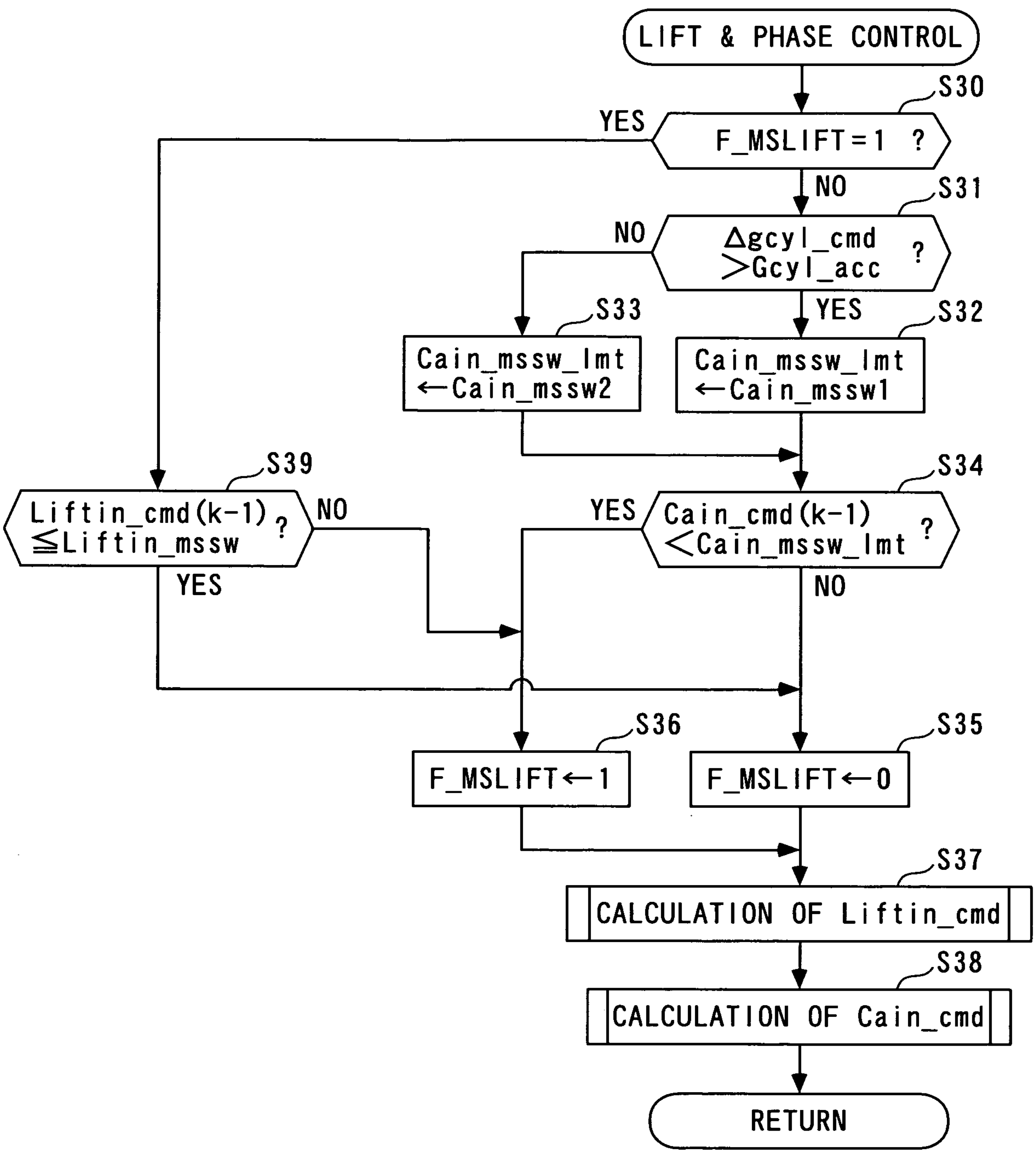

LIFT & PHASE CONTROL
S30
F_MSLIFT=1 ?
YES
NO
S31
Δgcyl_cmd
>Gcyl_acc ?
NO
YES
S33
Cain_mssw_lmt
←Cain_mssw2
S32
Cain_mssw_lmt
←Cain_mssw1
S39
Liftin_cmd(k-1)
≦Liftin_mssw ?
NO
YES
S34
Cain_cmd(k-1)
<Cain_mssw_lmt ?
YES
NO
S36
F_MSLIFT←1
S35
F_MSLIFT←0
S37
CALCULATION OF Liftin_cmd
S38
CALCULATION OF Cain_cmd
RETURN

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FIG. 39

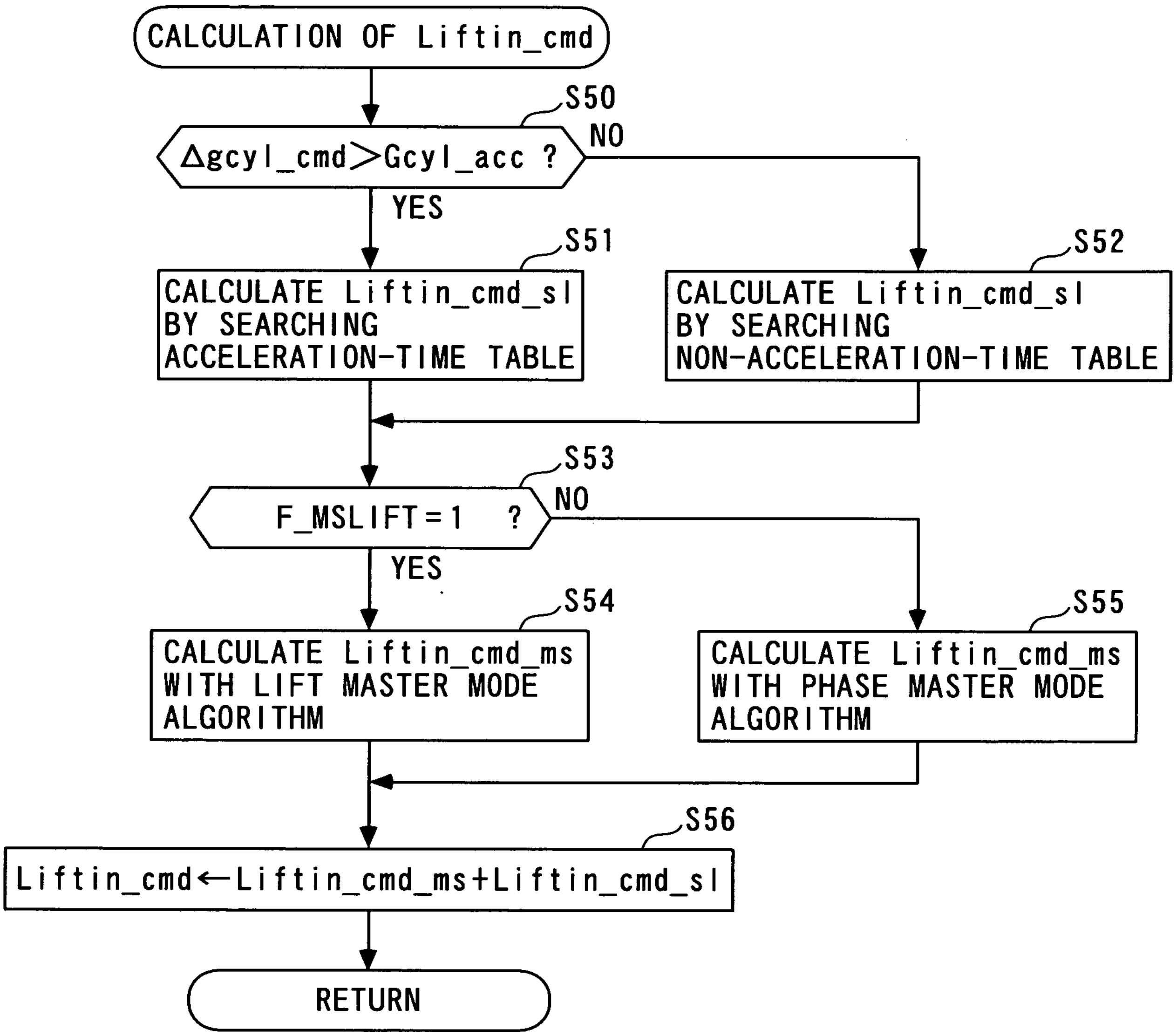

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FIG. 40

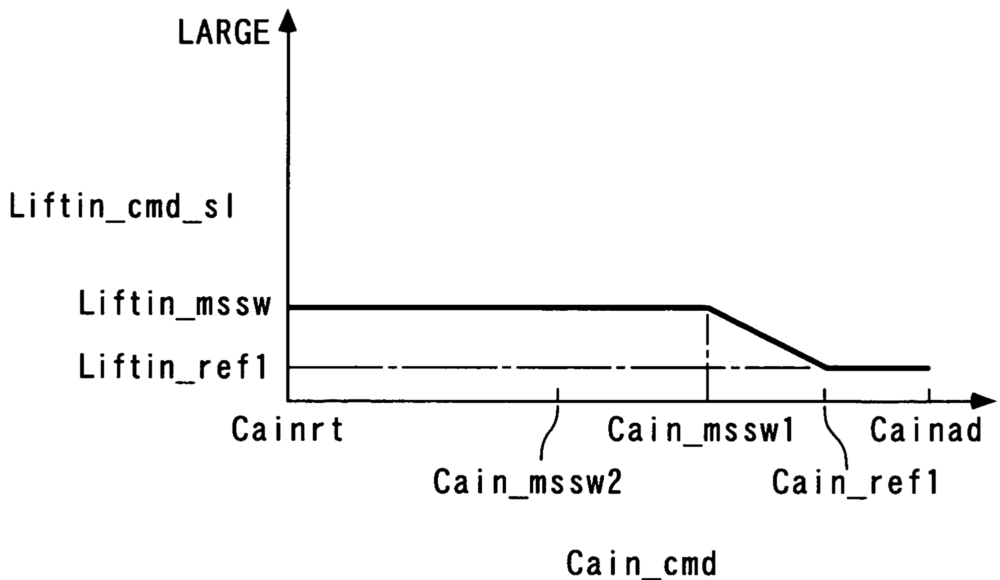


FIG. 41

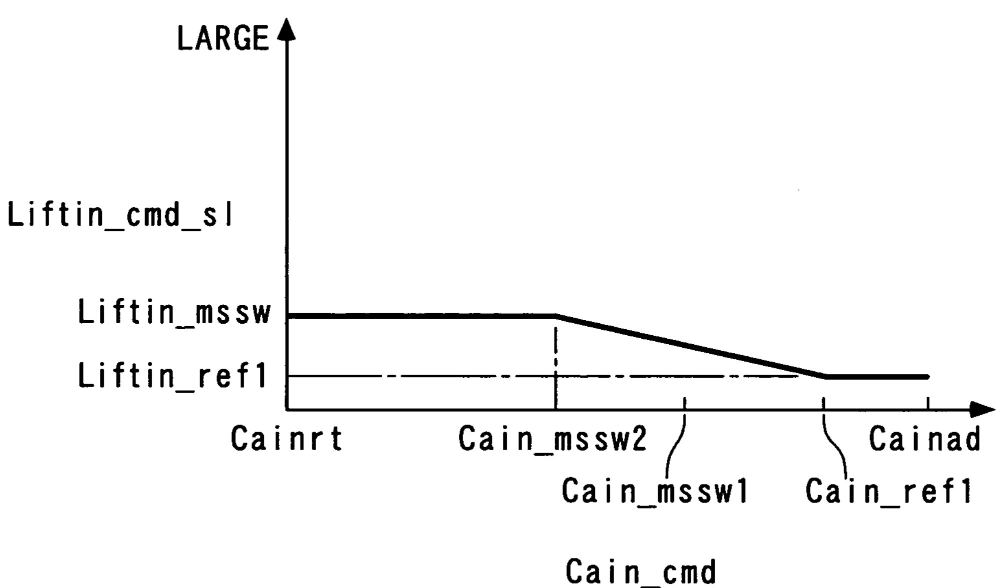


FIG. 42

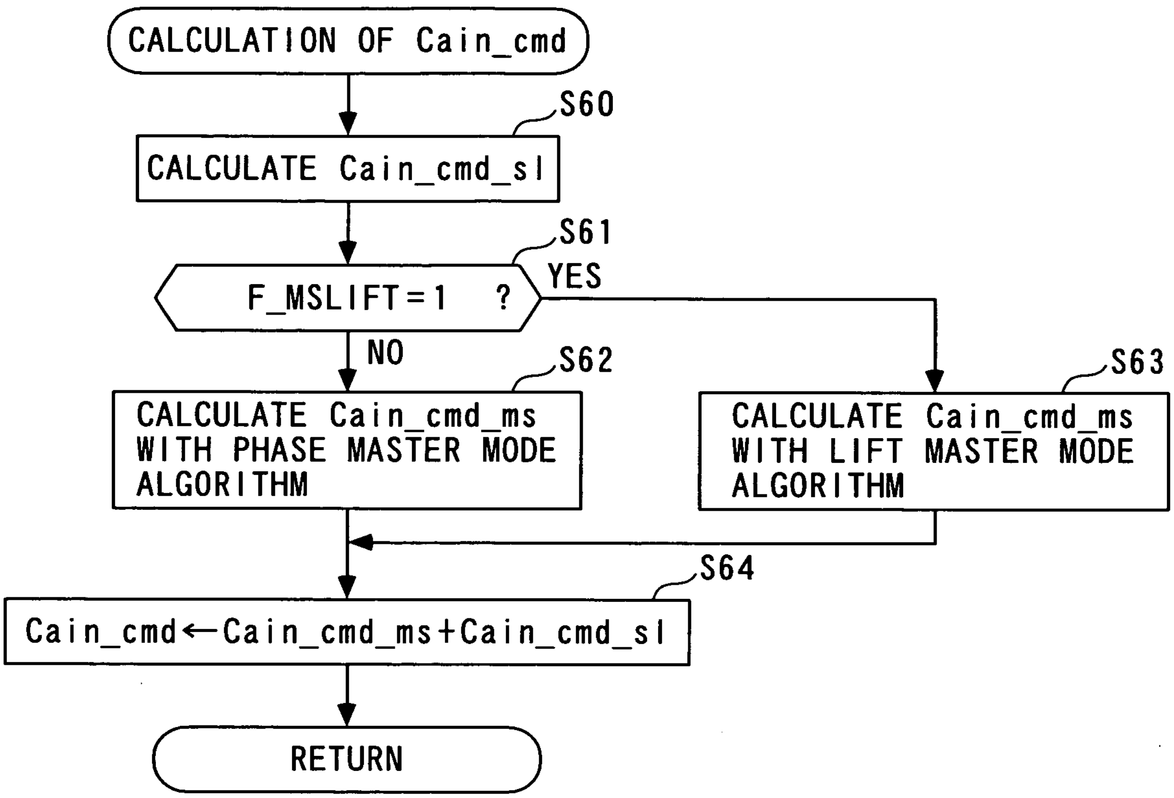
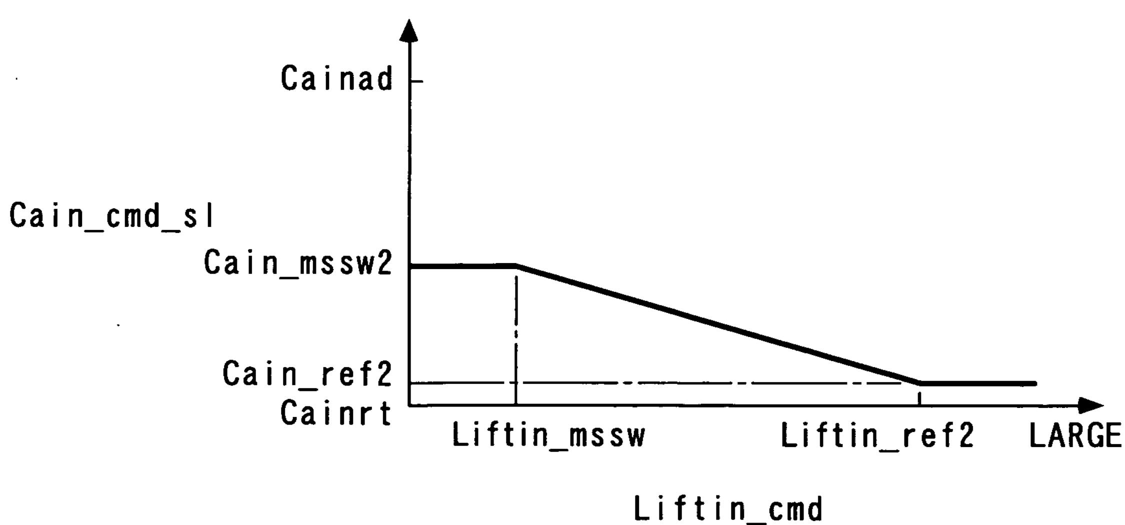

CALCULATION OF Cain_cmd
S60
CALCULATE Cain_cmd_sl
S61
F_MSLIFT=1 ?
YES
NO
S62
CALCULATE Cain_cmd_ms WITH PHASE MASTER MODE ALGORITHM
S63
CALCULATE Cain_cmd_ms WITH LIFT MASTER MODE ALGORITHM
S64
Cain_cmd←Cain_cmd_ms+Cain_cmd_sl
RETURN

FIG. 43


Cainad
Cain_cmd_sl
Cain_mssw2
Cain_ref2
Cainrt
Liftin_mssw
Liftin_ref2
LARGE
Liftin_cmd

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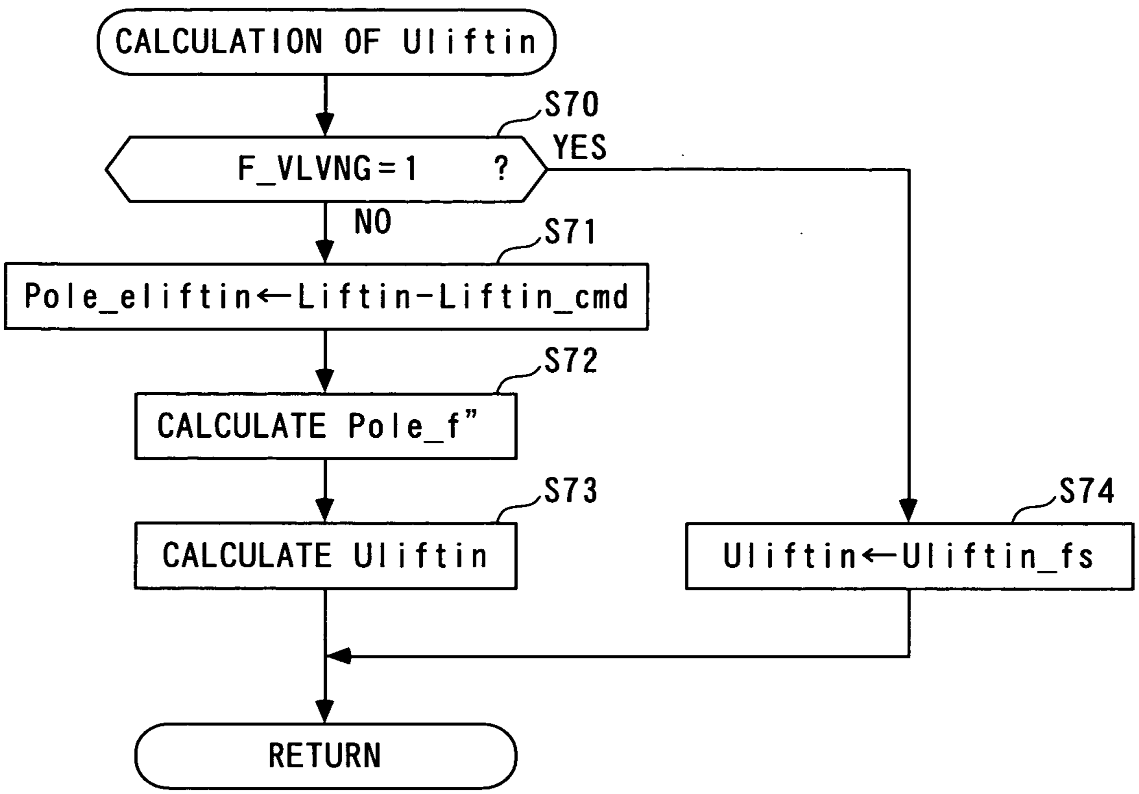
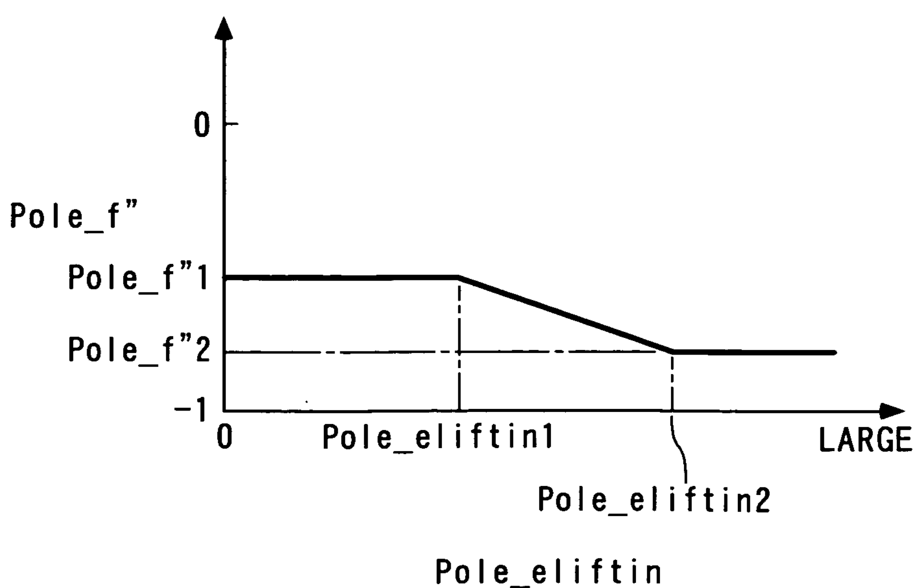
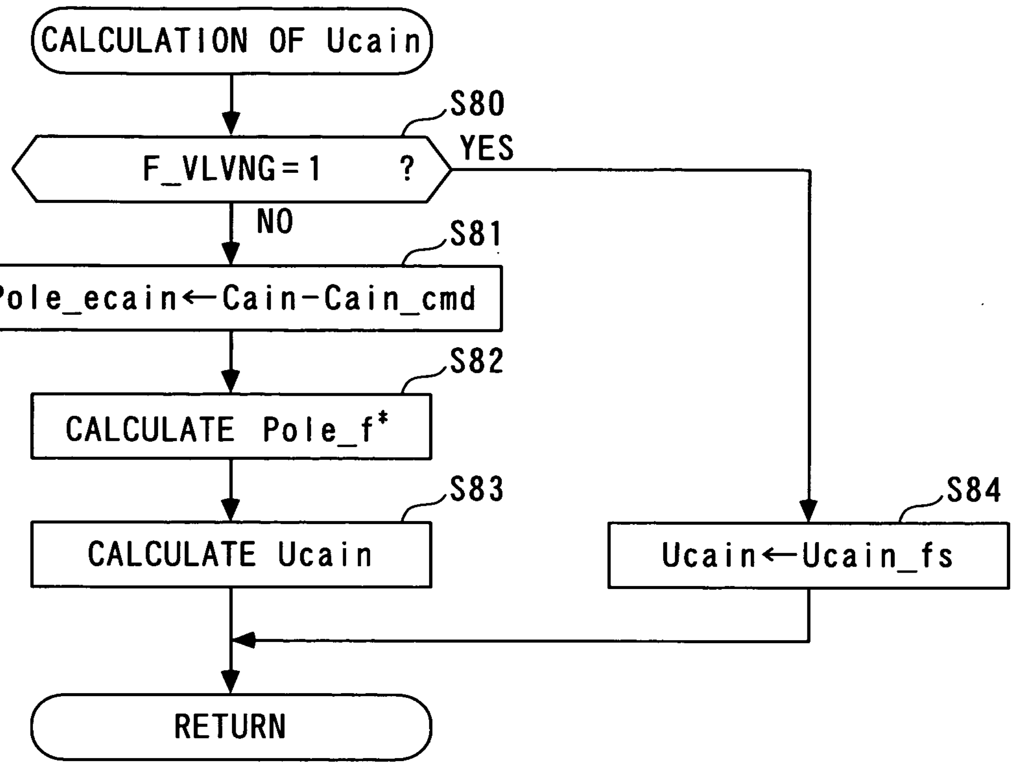
F I G. 44



F I G. 45



F I G. 46


CALCULATION OF Ucain
S80
F_VLVNG=1 ?
YES
NO
S81
Pole_ecain←Cain−Cain_cmd
S82
CALCULATE Pole_f*
S83
CALCULATE Ucain
S84
Ucain←Ucain_fs
RETURN

F I G. 47

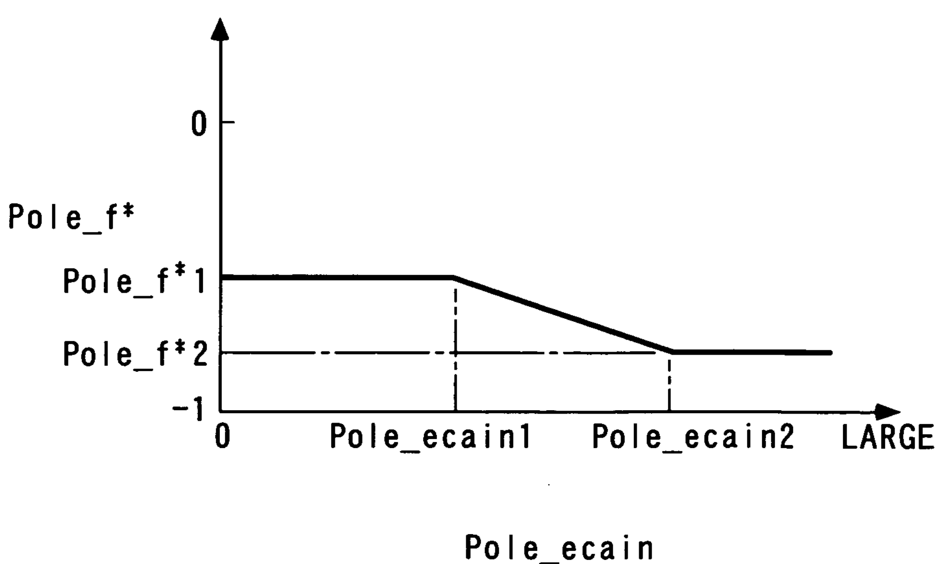

0
Pole_f*
Pole_f*1
Pole_f*2
−1
0
Pole_ecain1
Pole_ecain2
LARGE
Pole_ecain

FIG. 48

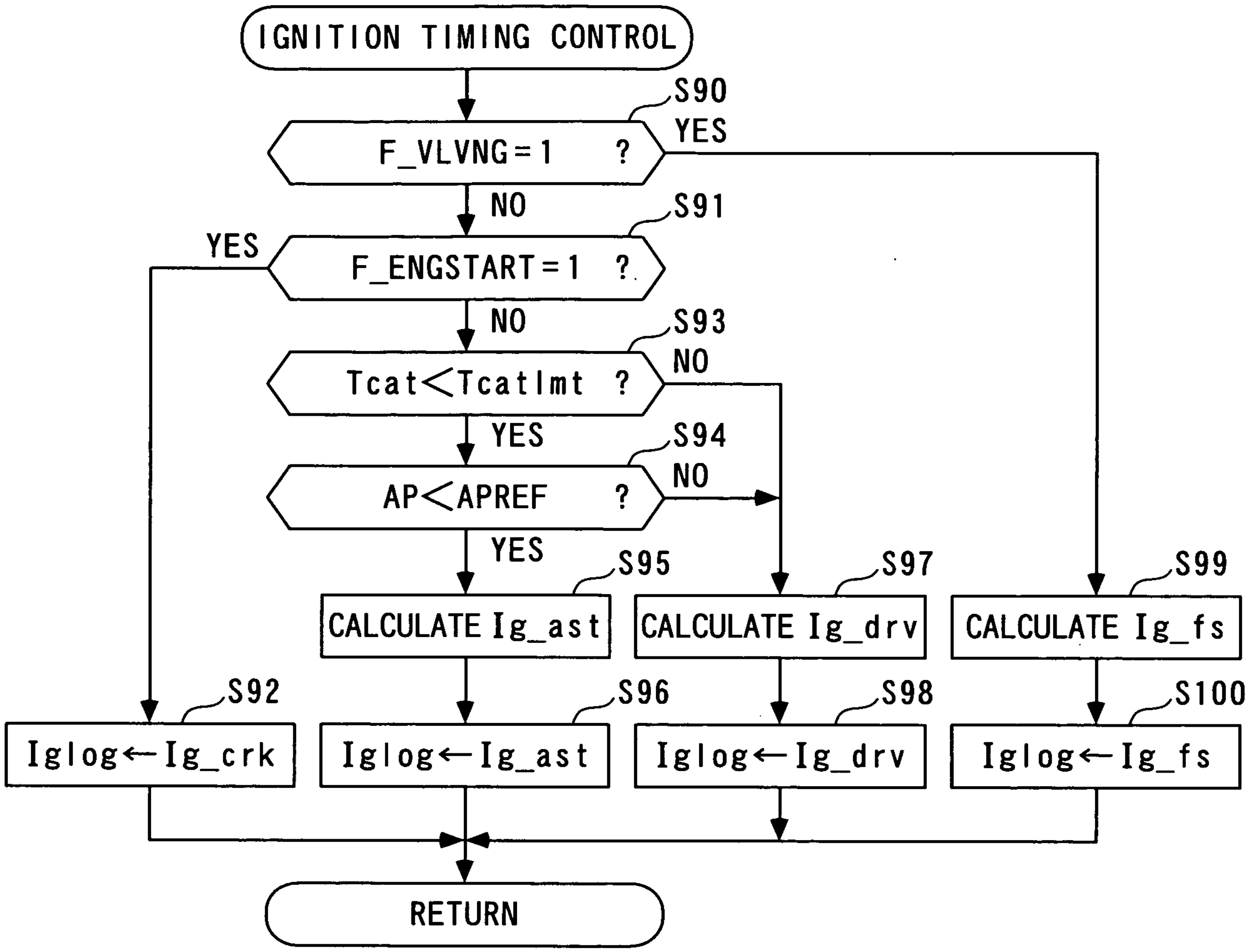

IGNITION TIMING CONTROL
S90
F_VLVNG=1 ?
YES
NO
S91
F_ENGSTART=1 ?
YES
NO
S93
Tcat<Tcatlmt ?
NO
YES
S94
AP<APREF ?
NO
YES
S95
CALCULATE Ig_ast
S97
CALCULATE Ig_drv
S99
CALCULATE Ig_fs
S92
Iglog←Ig_crk
S96
Iglog←Ig_ast
S98
Iglog←Ig_drv
S100
Iglog←Ig_fs
RETURN

FIG. 49

$$Ig\_ast = Ig\_ast\_base - Krch^{\#} \cdot \sigma^{\#}(m) - Kadp^{\#} \sum_{i=0}^{m} \cdot \sigma^{\#}(i) \quad \cdots\cdots (64)$$

$$\sigma^{\#}(m) = Enast(m) + POLE^{\#} \cdot Enast(m-1) \quad \cdots\cdots (65)$$

$$Enast(m) = NE(m) - NE\_ast \quad \cdots\cdots (66)$$

$$Ig\_fs = Ig\_fs\_base - Krch^{\#\#} \cdot \sigma^{\#\#}(m) - Kadp^{\#\#} \sum_{i=0}^{m} \cdot \sigma^{\#\#}(i) \quad \cdots\cdots (67)$$

$$\sigma^{\#\#}(m) = Enfs(m) + POLE^{\#\#} \cdot Enfs(m-1) \quad \cdots\cdots (68)$$

$$Enfs(m) = NE(m) - NE\_fs \quad \cdots\cdots (69)$$

FIG. 50

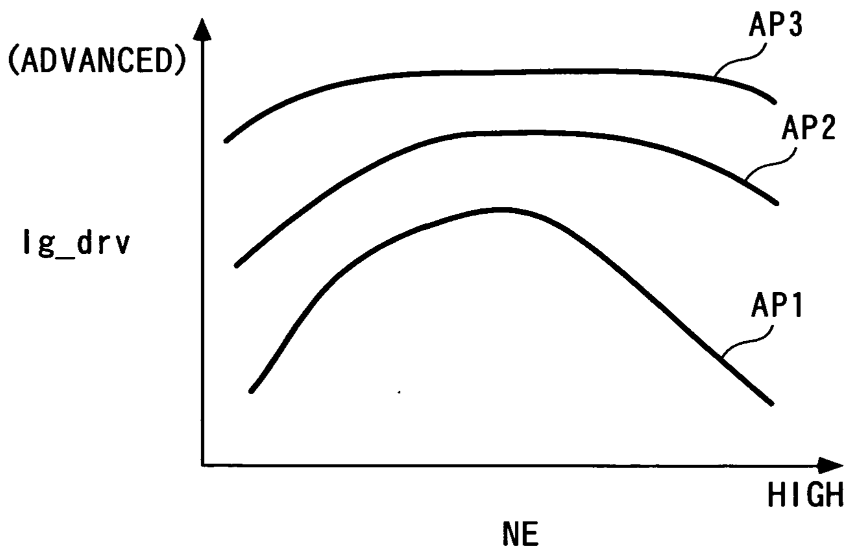


FIG. 51

$$Gcyl\_cmd\_f(k) = -POLE\_f \cdot Gcyl\_cmd\_f(k-1) + (1+POLE\_f) \cdot Gcyl\_cmd(k) \quad \cdots\cdots (70)$$

$$Liftin\_cmd\_ms(k) = Urch(k) + Uadp(k) \quad \cdots\cdots (71)$$

$$Urch(k) = -\frac{Krch}{b1} \cdot \sigma(k) \quad \cdots\cdots (72)$$

$$Uadp(k) = -\frac{Kadp}{b1} \cdot \omega(k) \quad \cdots\cdots (73)$$

$$\omega(k) = \omega(k-1) + \sigma(k) \quad \cdots\cdots (74)$$

$$\omega(k) = -\frac{Krch}{Kadp} \cdot \sigma(k) \quad \cdots\cdots (75)$$

$$\sigma(k) = Egc(k) + POLE \cdot Egc(k-1) \quad \cdots\cdots (76)$$

$$Egc(k) = Gcyl(k) - Gcyl\_cmd\_f(k) \quad \cdots\cdots (77)$$

FIG. 52

$$Gcyl\_cmd\_f(k) = -POLE\_f \cdot Gcyl\_cmd\_f(k-1) + (1+POLE\_f) \cdot Gcyl\_cmd(k) \quad \cdots\cdots (78)$$

$$Cain\_cmd\_ms(k) = Urch'(k) + Uadp'(k) \quad \cdots\cdots (79)$$

$$Urch'(k) = -\frac{Krch'}{b1} \cdot \sigma'(k) \quad \cdots\cdots (80)$$

$$Uadp'(k) = -\frac{Kadp'}{b1} \cdot \omega'(k) \quad \cdots\cdots (81)$$

$$\omega'(k) = \omega'(k-1) + \sigma'(k) \quad \cdots\cdots (82)$$

$$\omega'(k) = -\frac{Krch'}{Kadp'} \cdot \sigma'(k) \quad \cdots\cdots (83)$$

$$\sigma'(k) = Egc(k) + POLE' \cdot Egc(k-1) \quad \cdots\cdots (84)$$

$$Egc(k) = Gcyl(k) - Gcyl\_cmd\_f(k) \quad \cdots\cdots (85)$$

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